Feasibility Study for the information component of the Information and Training Centre for Water in Lebanon

Kick-off workshop

Water data challenges in Lebanon

Presented by:

Abbas Fayad, PhD

13 February 2018, Beirut, Lebanon

Coastal Basin

El Kelb

Area: ~ 440 km2

Snow contribution: ~30- 50%

Average annual discharge:

205 mcm yr-1 (SD ± 50)

CESBIO/CNRS (Fayad et al., 2017)
MoEW/UNDP (2014)
BGR (2012)

Transboundary Basin

Orontes

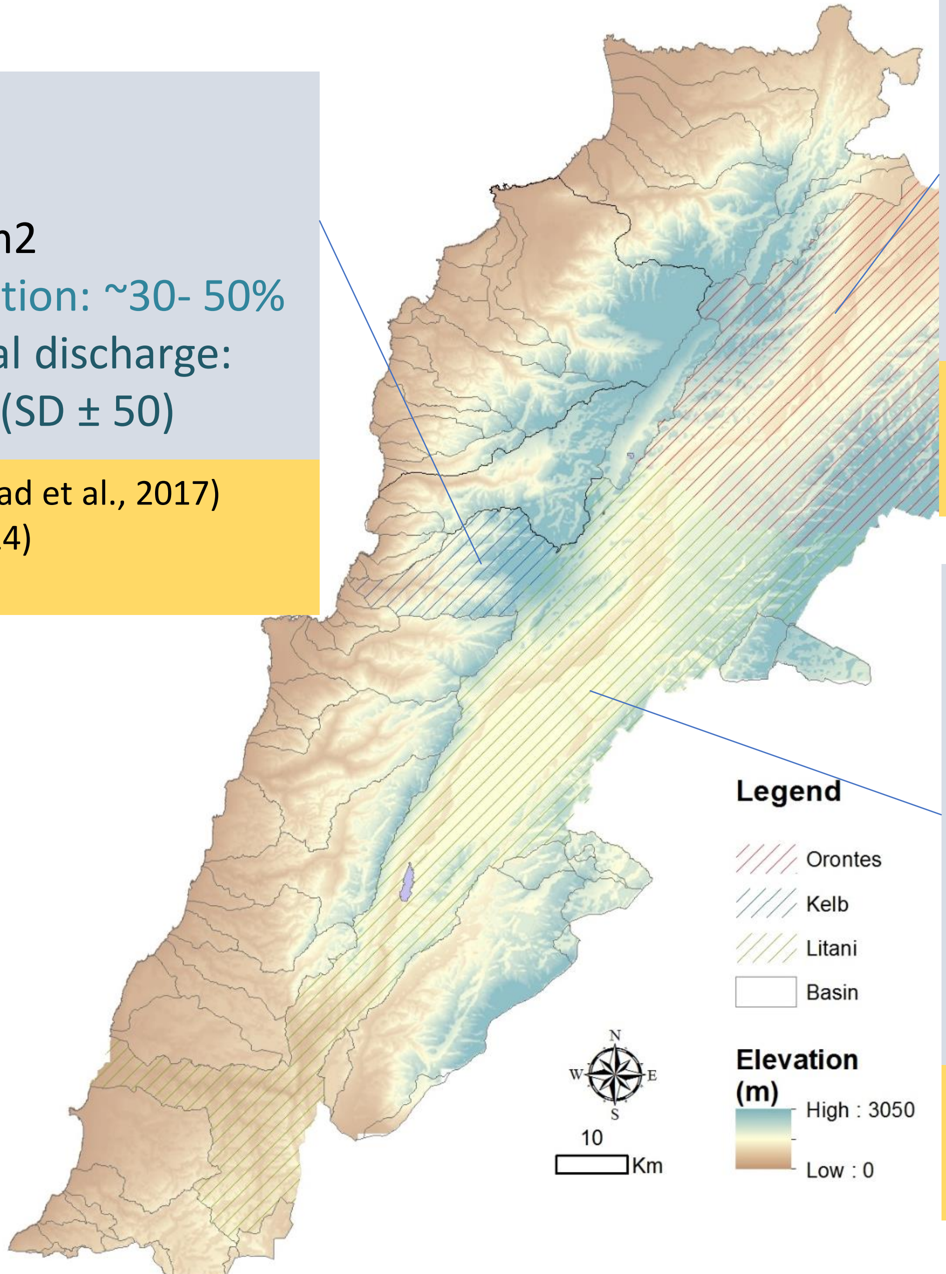
Area ~ 1870 km2

Snow contribution: ~35-60%

Average annual discharge:

325 mcm yr-1 (SD ± 125)

ICT (2014)
MOEW/UNDP (2014)
MedEU-WI/MoEW (2012)



Inland Basin

Litani

Area ~ 2180 km2

Snow contribution: ~10-20%

Average annual discharge,

Upper Litani:

235 mcm yr-1 (SD ± 70);

Lower Litani:

195 mcm yr-1 (SD ± 75)

MoEW/UNDP (2014)
MedEU-WI/MoEW (2012)
Multiple research institutes

Background Issues

Water Dilemma: Water Quantity and Quality

- Water scarcity is one of the main problems currently facing Lebanon:
  - Limited water sources;
  - Increased water demands by all sectors;
  - Inefficiencies in water supply systems and in water use.
- Recurring drought events resulted in low river flows, shorter snow seasons, depleted groundwater storage, depleted reservoirs, and water shortages.
- Increasing pollution of water resources (contributing to water scarcity):
  - Associated to human, agricultural, and industrial activities.

Water Data

what water data are gathered at the national scale?

- Meteorology
  - Precipitation, snowfall
  - Temperature
  - Humidity, wind speed, etc.
- Hydrology
  - Stream flows
  - Snow Water Equivalent (SWE)
- Hydrogeology
  - Water wells, water levels
  - Tracer tests, isotope analysis
  - Spring discharge
- Drinking water and water use for agriculture
  - Water supply and water consumption by source and users
- Environmental
  - Water samples from groundwater and surface-water bodies
- Hydraulic
  - Structure, systems, pumps, etc.
  - Water reservoirs, dams
  - Water distribution networks, sewer networks

- Continuous data
- Intermittent data
- Discontinuous data
- Inventory data

source of water data?

- Inventory
- Observations
- Remote sensing
- Estimation
- Modeling
- Prediction

Data Representation

National Water Data Inventory (NWDI) - MoEW

- **Spatial data** derived from existing maps (e.g., soil, land cover, geology, and hydrogeology)
    - used to define the watershed physical and physiographic characteristics (e.g., land use/cover, soil groups, groundwater aquifers/aquitard, drainage networks, rivers and streams, etc);
- **Temporal data** including hydrologic and climatologic observation from gauging and meteorological stations
    - time series data (e.g., river flow/discharge, temperature, precipitation, snowfall, humidity, evaporation, etc);
- **Spatio-temporal data** (hydrologic, climatologic & other data)
    - e.g., precipitation, evapotranspiration, snow water equivalent, land use;
- **Water data** (inc. agricultural, socio-economic data, and census);
- **Supplementary data** (i.e., attribute data)
    - additional information on the spatial hydrologic data (e.g., hydrologic characteristics of soil units and hydrogeologic parameters of aquifers).

Data Representation

Data Formats

Data format/source	Extension	Data types	Example Data
Hard copy	NA	Inventory data	- Reports - Observations - Companion map files - Maps
Excel Spreadsheet/ Access database	.xls, .xlsx .mdb	Continuous, Intermittent, Discontinuous	- Time series meteorology and hydrology - Census data
Shapefile/Coverage	.shp/coverage	Inventory data	- Land use land cover - Geology - Hydrogeology - Soil - Contour
Remote sensing	.img, .tif, .nc	Continuous, Discontinuous	- Snow cover area - Evapotranspiration - Soil moister - Precipitation
Raster	.img, .tif, grid	Inventory data	- DEM

National Hydrologic Geodatabase (NHG) - MoEW

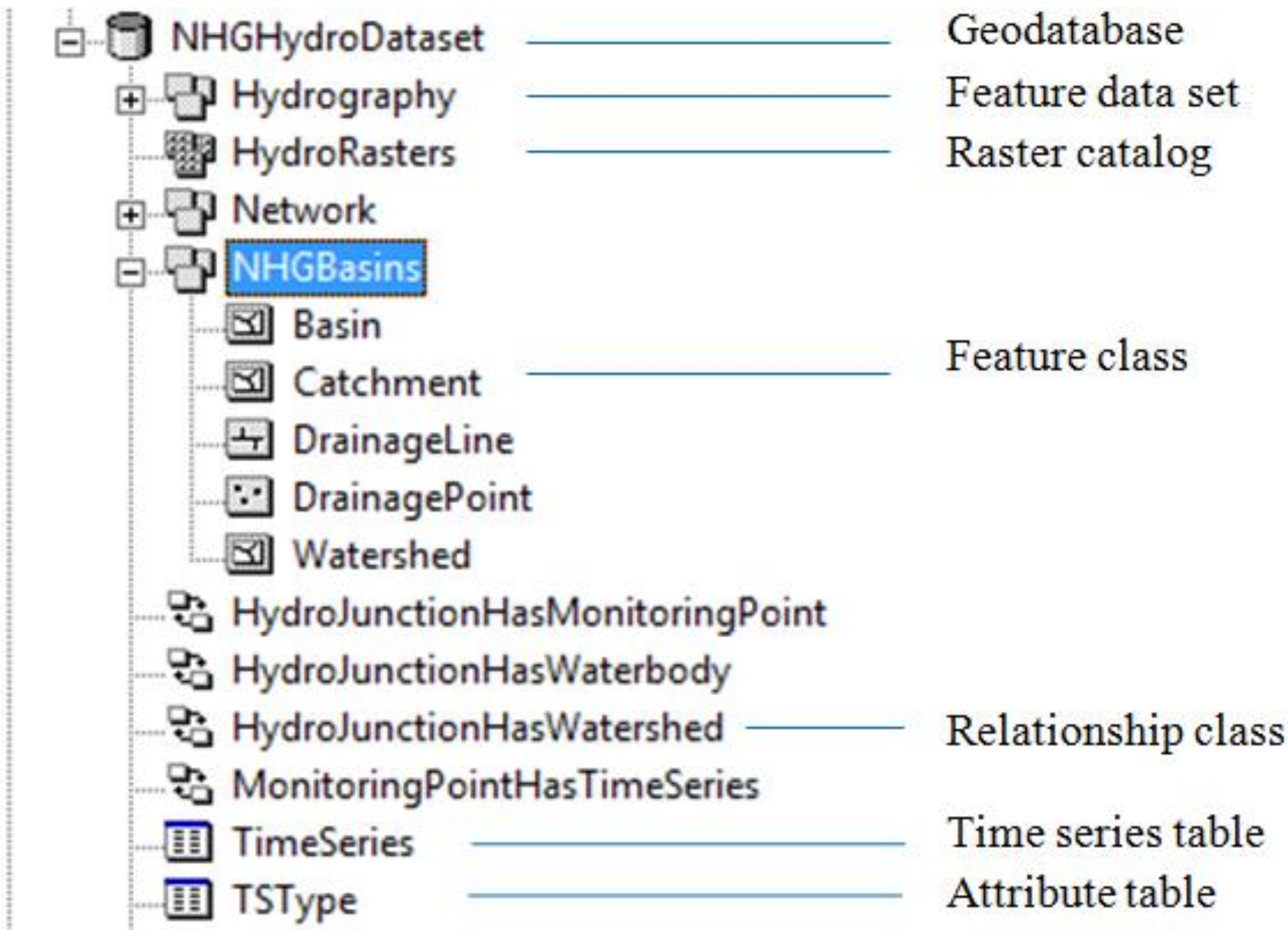
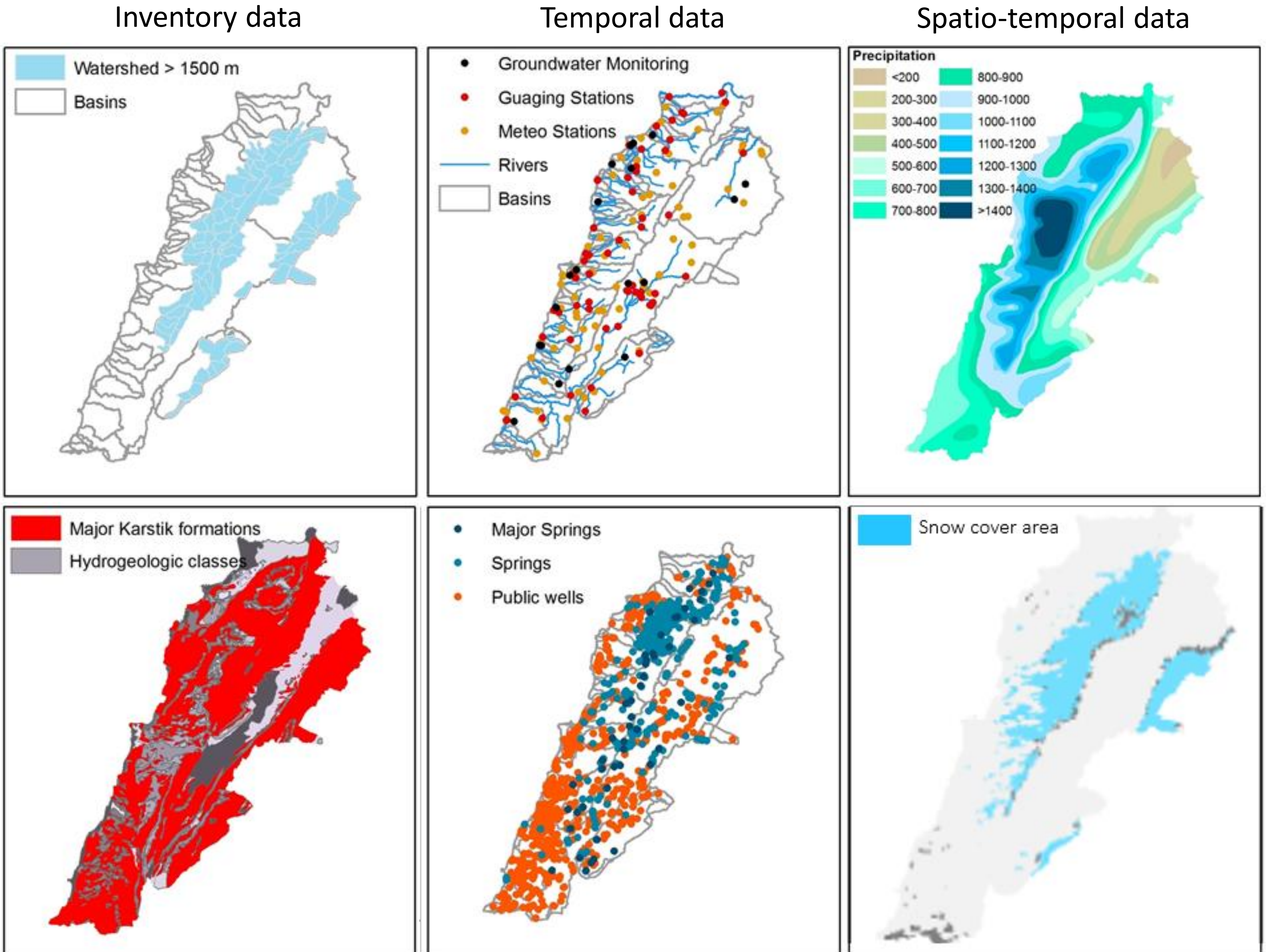
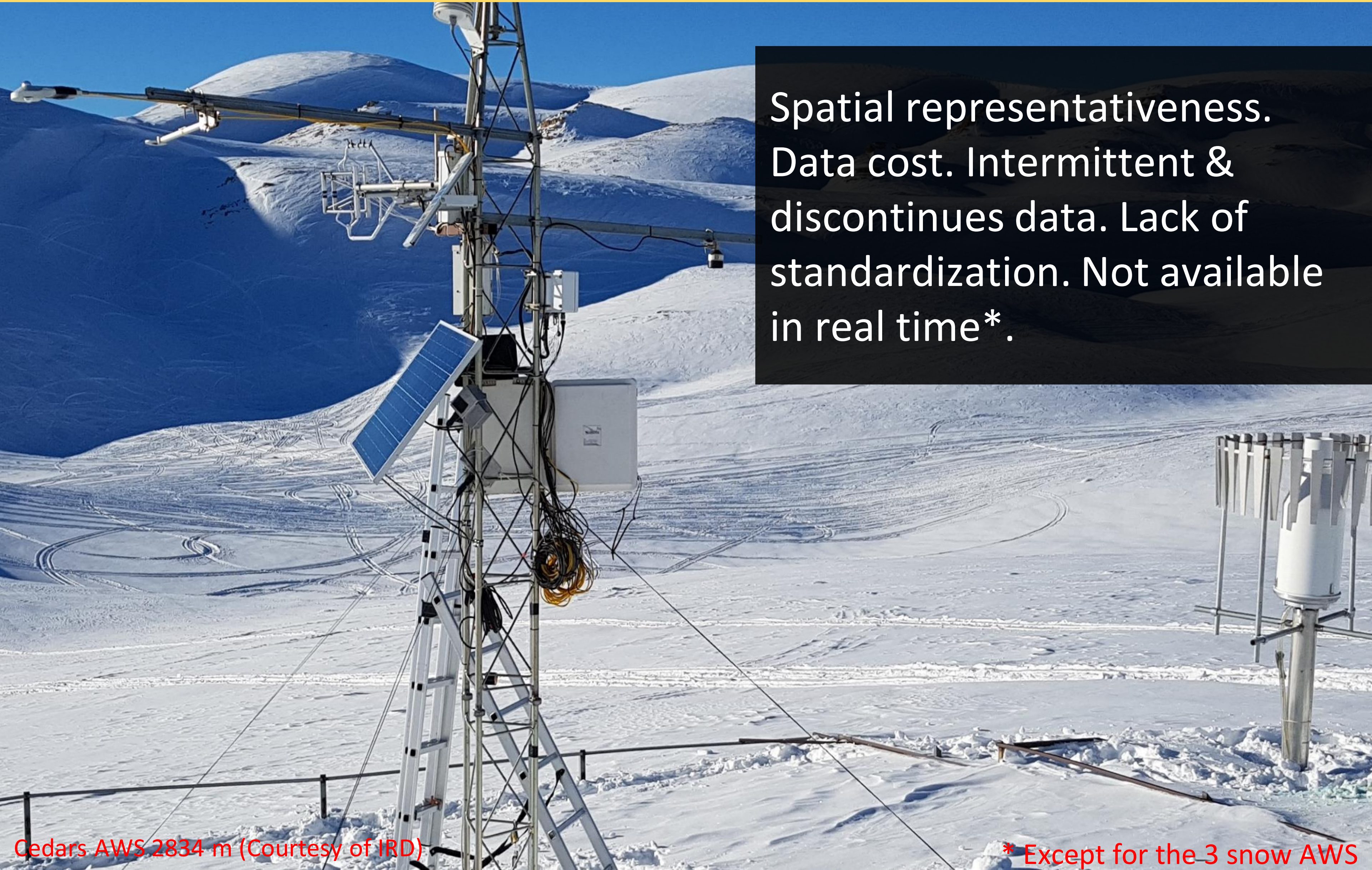


Fig. National Hydrologic Geodatabase (NHG)


Inventory data
Temporal data
Spatio-temporal data
Watershed > 1500 m
Basins
Groundwater Monitoring
Guaging Stations
Meteo Stations
Rivers
Basins
Precipitation
<200
200-300
300-400
400-500
500-600
600-700
700-800
800-900
900-1000
1000-1100
1100-1200
1200-1300
1300-1400
>1400
Major Karstik formations
Hydrogeologic classes
Major Springs
Springs
Public wells
Snow cover area

Challenges of Real-Time Water Data Acquisition and Management

Meteorology



Spatial representativeness. Data cost. Intermittent & discontinues data. Lack of standardization. Not available in real time*.

Cedars AWS 2834 m (Courtesy of IRD)

* Except for the 3 snow AWS

Challenges of Real-Time Water Data Acquisition and Management

Meteorology

- Weather stations are operated by:
  - Lebanese National Meteorological Service (LNMS);
  - Lebanese Agricultural Research Institute (LARI).
  - Institut de recherche pour le développement (IRD), USJ & CNRS (LB)
- Data most of the time not available in real time;
- Data not freely available (for meteorological data from LNMS);
- Major gap in the time series of meteorological data between 1975 and 1990;
- **A limited number of operational weather stations are located in the Mountain regions (elevation > 1000m)**;
- Number of operational stations:
  - 37 stations operated by the LNMS*
  - 23 stations operated by the LARI*
  - 3 stations operated by IRD/USJ/CNRS
- **Total number of required new stations is 89 of which 20 are snow stations (UNDP, 2014)**.

* The number of stations with continuous records is less than the number reported here

Challenges of Real-Time Water Data Acquisition and Management

Meteorology

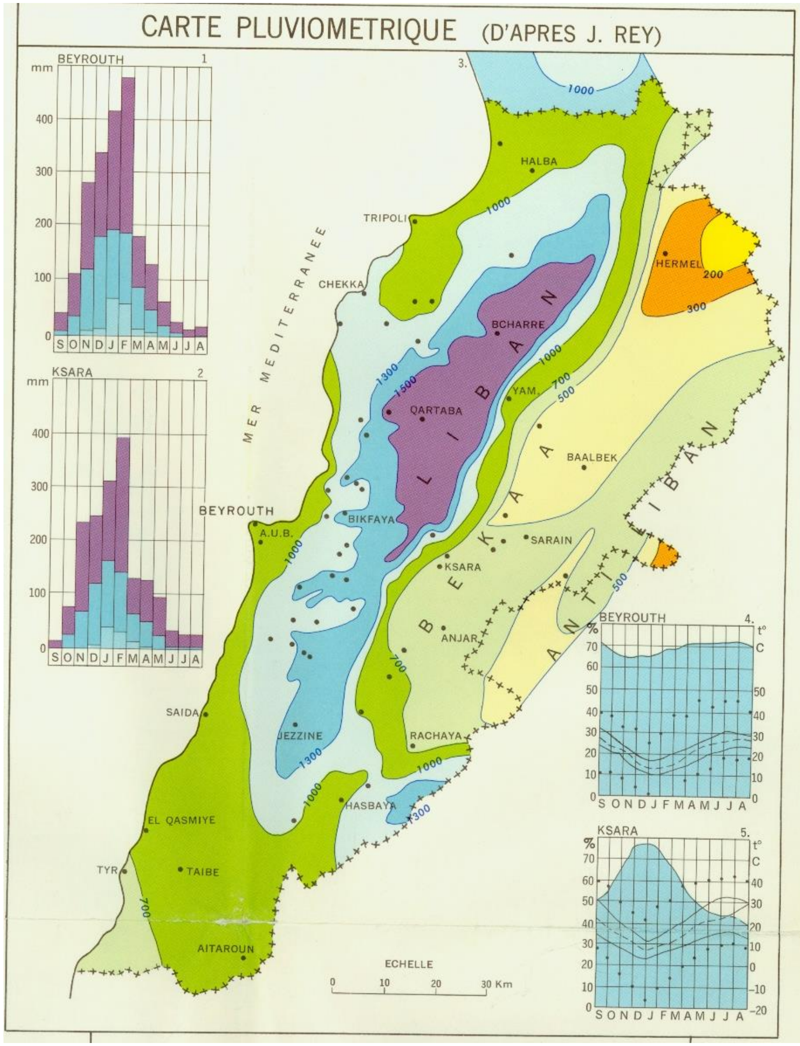


Fig. Precipitation map of Lebanon (circa 1970)

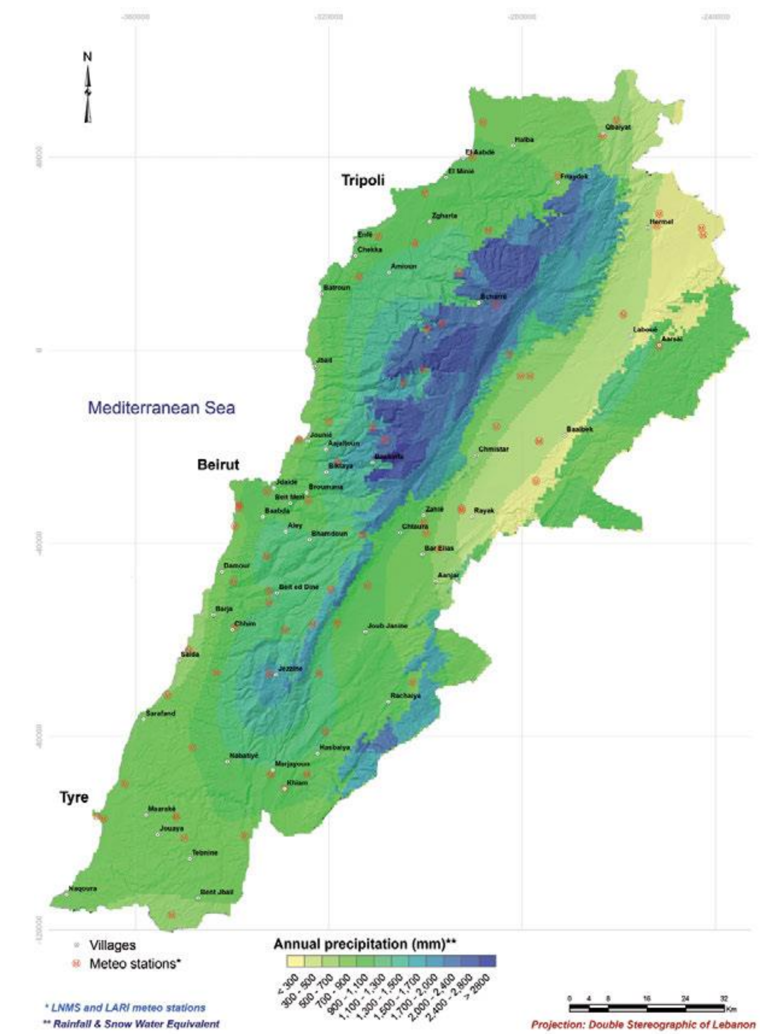


Fig. Annual precipitation 2011-2012 (UNDP, 2014)

Challenges of Real-Time Water Data Acquisition and Management

Snow

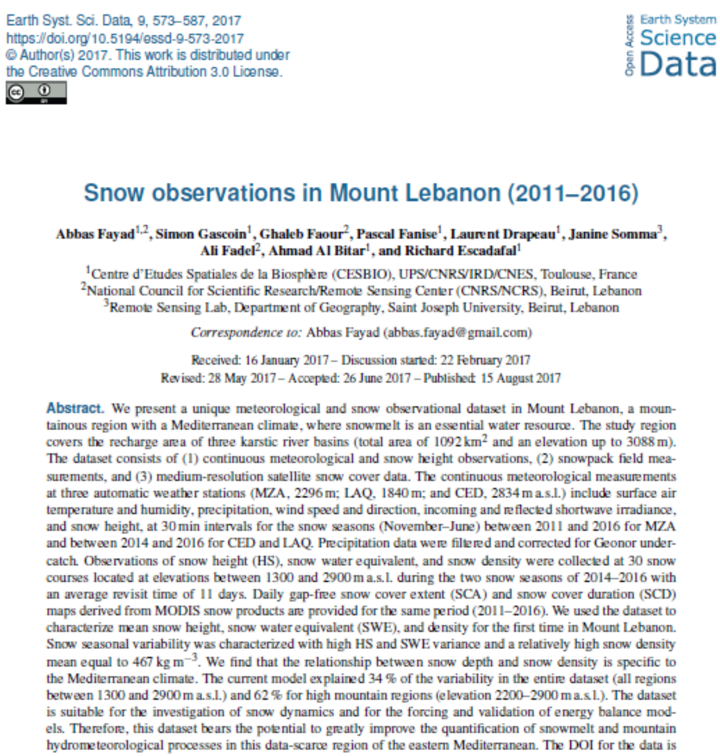
SWE, snow depth, snow density? their spatio-temporal variability? Field work: cost, planning, and logistics.

Cedars 2800 m, 12 Jan 2016 (Photo: A. Fayad)

Challenges of Real-Time Water Data Acquisition and Management
Snow

Snow Observatory:

- Collaboration between CESBIO & IRD (FR), USJ (LB), & CNRS (LB);
- 3 AWS (1850, 2300, 2850 m);
- Fully operational since 2013;
- Data freely available at Fayad et al. 2017 (ESSD-2017-3)


Earth Syst. Sci. Data, 9, 573–587, 2017
https://doi.org/10.5194/essd-9-573-2017

Open Access Earth System Science Data

Snow observations in Mount Lebanon (2011–2016)

Abbas Fayad[1,2], Simon Gascoin[1], Ghaleb Faour[2], Pascal Fanise[1], Laurent Drapeau[1], Janine Somma[3], Ali Fadel[2], Ahmad Al Bitar[1], and Richard Escadafal[1]

[1]Centre d'Etudes Spatiales de la Biosphère (CESBIO), UPS/CNRS/IRD/CNES, Toulouse, France
[2]National Council for Scientific Research/Remote Sensing Center (CNRS/NCRS), Beirut, Lebanon
[3]Remote Sensing Lab, Department of Geography, Saint Joseph University, Beirut, Lebanon

Correspondence to: Abbas Fayad (abbas.fayad@gmail.com)

Received: 16 January 2017 – Discussion started: 22 February 2017
Revised: 28 May 2017 – Accepted: 26 June 2017 – Published: 15 August 2017

Abstract. We present a unique meteorological and snow observational dataset in Mount Lebanon, a mountainous region with a Mediterranean climate, where snowmelt is an essential water resource. The study region covers the recharge area of three karstic river basins (total area of 1092 km^2 and an elevation up to 3088 m). The dataset consists of (1) continuous meteorological and snow height observations, (2) snowpack field measurements, and (3) medium-resolution satellite snow cover data. The continuous meteorological measurements at three automatic weather stations (MZA, 2296 m; LAQ, 1840 m; and CED, 2834 m a.s.l.) include surface air temperature and humidity, precipitation, wind speed and direction, incoming and reflected shortwave irradiance, and snow height, at 30 min intervals for the snow seasons (November–June) between 2011 and 2016 for MZA and between 2014 and 2016 for CED and LAQ. Precipitation data were filtered and corrected for Geonor undercatch. Observations of snow height (HS), snow water equivalent, and snow density were collected at 30 snow courses located at elevations between 1300 and 2900 m a.s.l. during the two snow seasons of 2014–2016 with an average revisit time of 11 days. Daily gap-free snow cover extent (SCA) and snow cover duration (SCD) maps derived from MODIS snow products are provided for the same period (2011–2016). We used the dataset to characterize mean snow height, snow water equivalent (SWE), and density for the first time in Mount Lebanon. Snow seasonal variability was characterized with high HS and SWE variance and a relatively high snow density mean equal to 467 $kg\,m^{-3}$. We find that the relationship between snow depth and snow density is specific to the Mediterranean climate. The current model explained 34 % of the variability in the entire dataset (all regions between 1300 and 2900 m a.s.l.) and 62 % for high mountain regions (elevation 2200–2900 m a.s.l.). The dataset is suitable for the investigation of snow dynamics and for the forcing and validation of energy balance models. Therefore, this dataset bears the potential to greatly improve the quantification of snowmelt and mountain hydrometeorological processes in this data-scarce region of the eastern Mediterranean. The DOI for the data is https://doi.org/10.5281/zenodo.583733.

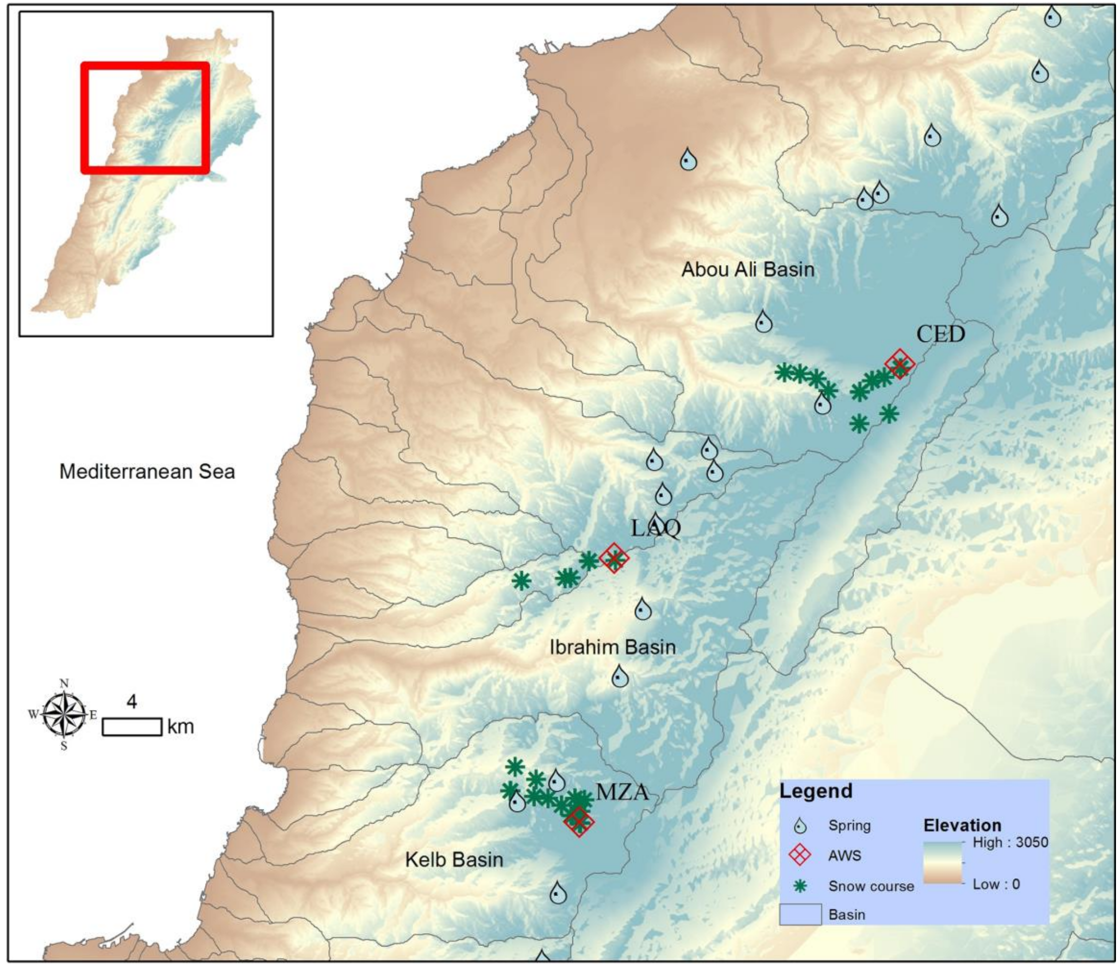


Fig. Location of the AWSs in Mount Lebanon. Points indicates the location of the 30 snow courses (HS, SWE, and snow density) for the elevation range between 1350 and 2900 m (2014–2016)

Challenges of Real-Time Water Data Acquisition and Management

Hydrology

Intermittent/discontinues data. Lack of standardization. Not available in real time.

Water monitoring stations (limnigraphs), courtesy of LRA

Challenges of Real-Time Water Data Acquisition and Management

Hydrogeology

Snow fed, karstic system, lack of monitoring network.

Balaa 1500 m, 20 Feb 2016 (Photo: A. Fayad)

Hydrology and Hydrogeology

- Surface and groundwater resources are monitored by the Litani River Authority (LRA);
- LRA is measuring surface water in all Lebanese rivers and springs:
  - Data is reported on daily basis;
  - **A number of gauge measurements are provided on monthly basis;**
  - **Few gauges are located in the snow dominated regions of Lebanon, above 1200m.**
- Measuring the level of groundwater via water wells:
  - **Limited to the Bekaa and the South of Lebanon**;
- **The karst regions, namely the Mount Lebanon and Anti Lebanon, are not monitored**:
  - Measurements in the karst are available, for specific regions and over a limited time period, from projects – e.g., BGR (2013) and UNDP (2014).

Challenges of Real-Time Water Data Acquisition and Management

Hydrology and Hydrogeology

LITANI RIVER AUTHORITY

Annual Summary of daily data - flow

Station Number : 363 **Name : LITANI - Joub Jannine**

Basin number : 100 Latitude : 33:38:21 Longitude : 35:46:48 Altitude : 859,7 m

Area : 1433.00 km²

Year : 2009/2010

Day\Month	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
1	0.000	1.359	2.562	2.145	13.381	22.330	19.540	12.324	0.877	0.437	0.000	0.000
2	0.000	1.336	2.730	2.157	12.755	24.282	41.546	12.302	0.907	0.422	0.000	0.000
3	0.000	1.308	4.091	2.244	11.984	24.678	46.070	12.168	0.899	0.401	0.000	0.000
4	0.000	1.298	4.538	5.266	11.750	25.157	49.169	11.823	0.954	0.373	0.000	0.000
5	0.000	1.281	8.907	5.261	11.682	25.315	34.452	10.920	0.856	0.341	0.000	0.000
6	0.000	1.394	6.633	5.457	11.612	26.322	19.735	10.117	0.752	0.309	0.000	0.000
7	0.000	1.381	5.326	7.243	11.569	26.567	5.018	9.495	0.732	0.276	0.000	0.000
8	0.000	1.386	4.640	7.979	12.116	26.203	12.671	8.708	0.794	0.250	0.000	0.000
9	0.000	1.366	4.013	6.116	11.894	25.967	12.487	8.015	0.808	0.227	0.000	0.000
10	0.000	1.373	3.702	5.766	11.606	27.108	12.732	7.337	0.890	0.000	0.000	0.000
11	0.000	1.381	3.514	5.785	11.354	29.999	12.621	6.839	1.045	0.000	0.000	0.000
12	0.000	1.371	3.162	5.752	11.234	28.203	12.682	6.505	0.734	0.000	0.000	0.000
13	0.000	1.392	3.045	18.536	10.926	26.342	12.869	5.774	0.700	0.000	0.000	0.000
14	0.000	1.407	2.930	23.048	11.995	24.432	12.964	4.415	0.665	0.000	0.000	0.000
15	0.000	1.494	2.948	20.761	11.108	23.103	10.039	3.895	0.647	0.000	0.000	0.000
16	0.000	1.454	2.896	20.849	10.743	23.039	6.920	3.277	0.653	0.000	0.000	0.000
17	0.000	1.453	2.922	31.283	10.263	23.203	3.800	2.730	0.663	0.000	0.000	0.000
18	0.000	1.453	2.983	14.756	10.183	21.876	0.681	2.162	0.644	0.000	0.000	0.000
19	0.000	1.473	2.971	22.158	20.648	22.155	0.272	1.763	0.625	0.000	0.000	0.000
20	0.000	1.448	2.818	40.367	12.215	21.673	12.920	1.335	0.689	0.000	0.000	0.000
21	0.340	1.460	2.731	43.612	11.693	20.508	12.648	0.884	0.660	0.000	0.000	0.000
22	0.680	1.461	2.755	32.363	10.634	19.834	12.488	0.899	0.670	0.000	0.000	0.000
23	1.020	1.596	2.868	25.262	10.095	19.619	12.196	0.971	0.617	0.000	0.000	0.000
24	1.360	1.589	2.961	20.722	12.989	9.505	11.930	0.974	0.643	0.000	0.000	0.000
25	1.354	1.588	2.303	18.594	18.639	8.897	11.858	0.902	0.622	0.000	0.000	0.000
26	1.348	1.601	2.289	16.804	18.538	11.174	11.803	0.899	0.568	0.000	0.000	0.000
27	1.371	1.619	2.233	15.597	18.431	28.237	11.969	0.885	0.447	0.000	0.000	0.000
28	1.419	1.931	2.198	14.731	19.095	32.201	12.316	0.861	0.447	0.000	0.000	0.000
29	1.441	1.982	2.180	15.349	23.092		12.316	0.838	0.447	0.000	0.000	0.000
30	1.381	1.920	2.171	15.024	21.714		12.313	0.861	0.447	0.000	0.000	0.000
31		2.162		14.290	21.221		12.499		0.447		0.000	0.000

Fig. Example of raw daily flow data (courtesy of LRA).

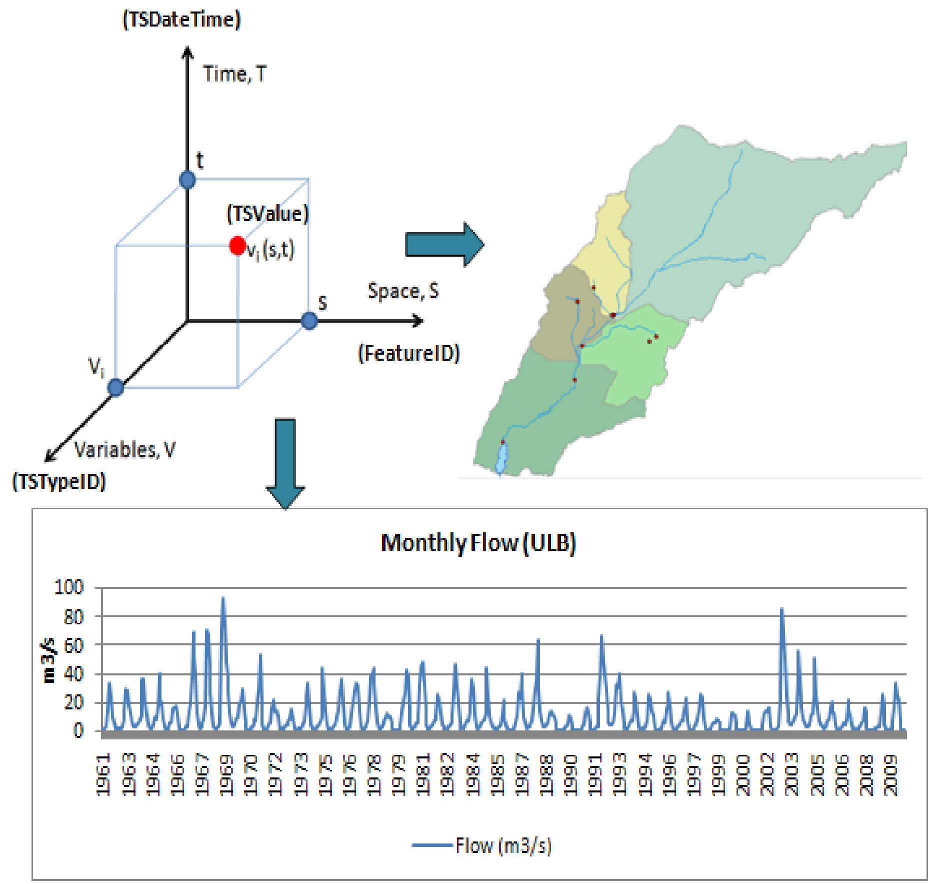


Fig. Standardizing of time series data using the hydro data model for describing time series data.

SEMIDE EMWIS

Water Quality

Limited water quality monitoring.

Sentinel-2 color IR, algae (magenta)
26-05-2016 to 18-09-2017

Projects

Font + - | SHARE

Challenges of Real-Time Water Data Acquisition and Management

Water Use and Water Management

Project of desalination plant at Hadath City

11 December , 2016

Project of desalination plant at Hadath City As part of the search for additional water sources, especially since the precipitation is steadily decreasing year after year In addition to the... more

---

Study for the project of constructing a reservoir and treatment plant in the Jamhour City and another in the gallery of Samaan City.

11 October , 2015

Study for the project of constructing a reservoir and treatment pl
gallery of Samaan City. As it has been shown that the quality of

---

New Reservoir Baysor 3000 m 3 and the Jisr Al-Kadi 1000 m

17 August , 2015

New Reservoir Baysor 3000 m 3 and the Jisr Al-Kadi 1000 m D
in the areas of Baysour and Jisr Al Kadi for improve the distribu

---

Limited information on water distribution networks; limited data on the operations of the utility networks. No water metering in Lebanon.

Project of drilling two wells at Siblin and Dmit.

23 August , 2014

Project of drilling two wells at Siblin and Dmit. To ensure the greatest amount of water in the areas of Dmit and Siblin, the Board of Directors approved t... more

Agricultural Water Use

Source: http://www.fao.org/nr/water/aquastat/countries_regions/LBN/

TABLE 3
Water use

Water withdrawal			
Total water withdrawal	2005	1 310	10^6 m^3/yr
- irrigation + livestock	2005	780	10^6 m^3/yr
- municipalities	2005	380	10^6 m^3/yr
- industry	2005	150	10^6 m^3/yr
• per inhabitant	2005	366	m^3/yr
Surface water and groundwater withdrawal	2005	1 263	10^6 m^3/yr
• as % of total actual renewable water resources	2005	28	%
Non-conventional sources of water			
Produced wastewater	[illegible]	[illegible]	[illegible]
Treated wastewater	[illegible]	[illegible]	[illegible]
Reused treated wastewater	[illegible]	[illegible]	[illegible]
Desalinated water produced	[illegible]	[illegible]	[illegible]
Reused agricultural drainage water	[illegible]	[illegible]	[illegible]

Limited information on irrigated areas. Limited information on water withdrawal for agriculture from all sources (wells, dams, lakes, reservoirs, and facilities).

Conclusion

Water Challenges and Opportunities

- Lack of a comprehensive hydrologic and water data management system at the national scale:
  - Inaccessibility to meteorological, hydrological, and water data in real time;
  - Incompatible data formats;
  - Absence of integrated open source water platform;
  - Fragmented and outdated information regarding water budget and water use.
- Lack of a standardized for storing water data:
  - Creating computerized water databases;
  - Mapping the locations of water reservoirs, distribution and sewer networks, etc;
  - Gathering records on the operations of the utility networks (water supply, waste water treatment plant, water treatment plant, etc.).
- Available meteorological/water data are difficult to sort, fragmented, disjointed, and incomplete, and not fully documented:
  - Increase the collection and sharing of data/information;
    - Meteorological, hydrological, environmental, and water data
  - Need for the quantification of **surface and ground water resources**
  - Need for the quantification of **snowpack contribution** in mountains (**particularly in karst**)

Conclusion

Institutional & Management Challenges and Opportunities

- Water resources exploitation and management is derived using coarse water demand/supply estimations:
  - Need for compiling data from many sources about how much water is used for different purposes (especially for agriculture);
  - Use a water resource model that integrates the hydrologic system and accounts for water supply, water distribution networks, water supply efficiency, system losses, and water planning and management practices.
- Disorganized water governance:
  - Limited governance, legislative, and institutional capacities;
  - Need to increase the collaboration between different governmental organizations.
- Inadequacy in the development of management and planning practices:
  - Derive scenarios using hydrologic and water resources models;
  - Evaluation of water resources management and water availability under different scenarios including population growth, agriculture expansion, increased water development, change in management practices, and projected climate changes.

Conclusion

Advancing the Understanding of Water Resources

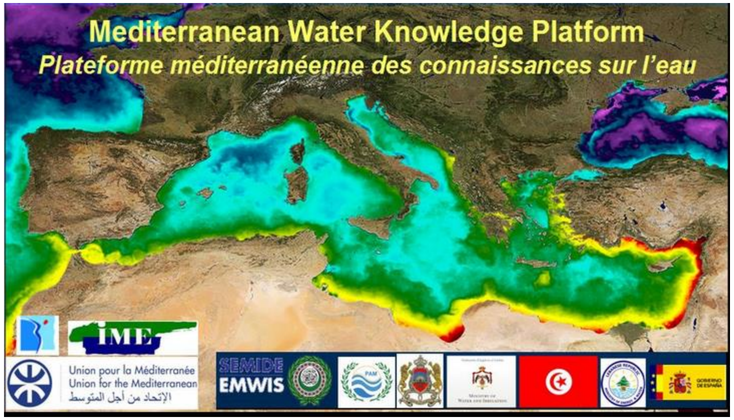
- Build a data inventory that reviews the existing national data and records;
- Facilitate access to meteorological, hydrological, and water information for the water community;
- Support the development, implementation, and maintenance of a hydrologic/water databases that improve data and information management by adopting a national cataloging standard;
- Advance the understanding of hydrologic and water processes and the related water environment and provide knowledge of the various components of the hydrologic and water resources systems;
- Promote and facilitate the dissemination and use of information technology in the fields of hydrology and water resources.

Feasibility Study for the information component of the Information and Training Centre for Water in Lebanon

Kick-off workshop

Abbas Fayad, PhD

abbas.fayad@gmail.com



www.semide.net/initiatives/MWKP