

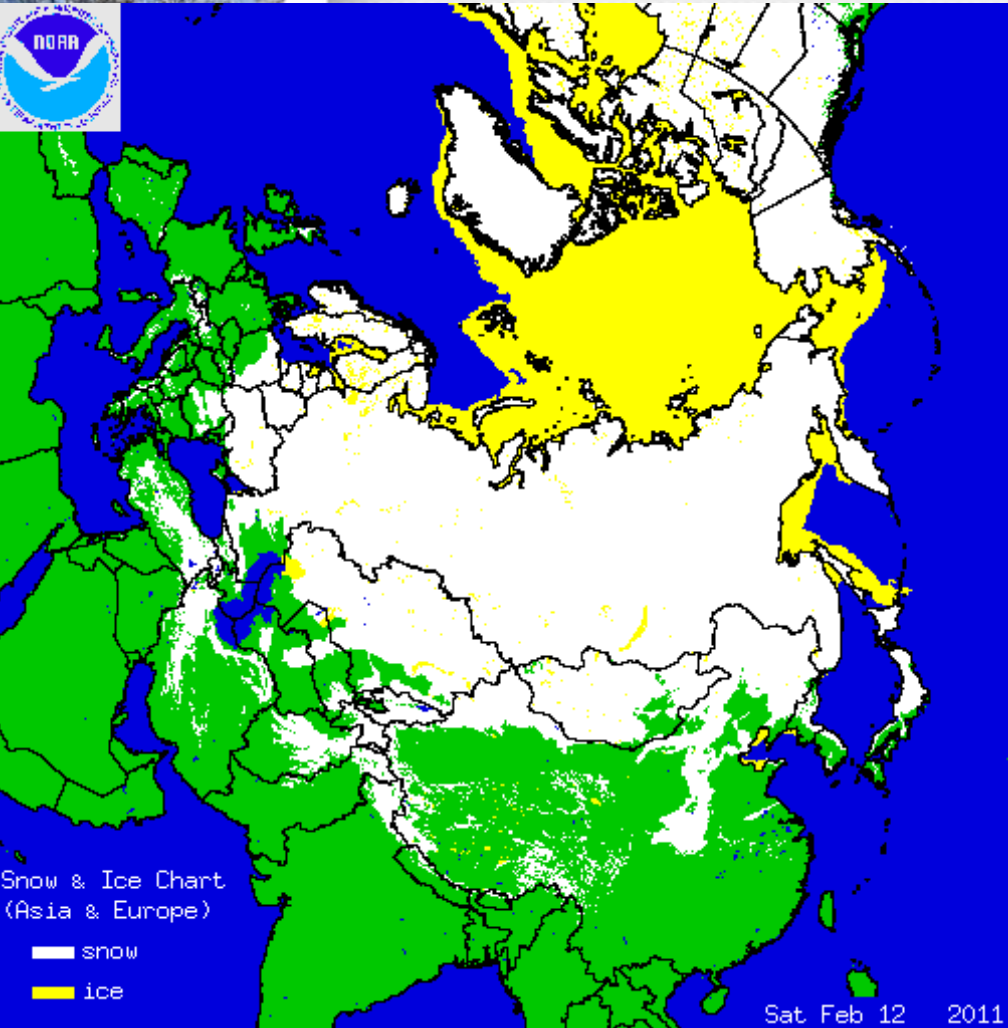
# Measuring Snow Components with New Methods and Validation using Satellite Images in Turkey

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*Anadolu University, Turkey*



Smolenice, Slovakia, September 2017

# Snow in Turkey



- ❄ Ave. elev. of Turkey > 1100 m, snow is frequent
- ❄ Snow stays on ground in East and Central Anatolia
- ❄ Most transboundary rivers are fed by snowmelt



# HARMOSNOW COST PROJECT

Harmosnow Joint Event on International Workshop  
1st Field Campaign & Meetings  
March 2016 Erzurum, Turkey





# Snow Measurements in Turkey

❄ Manual snow courses  
(1960's)

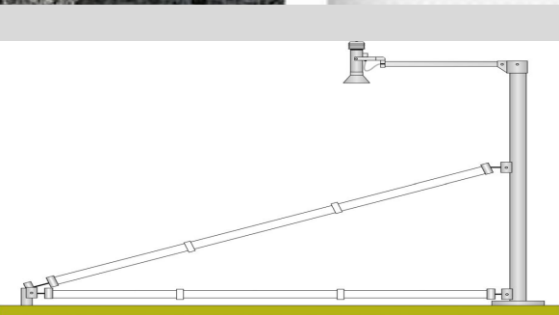
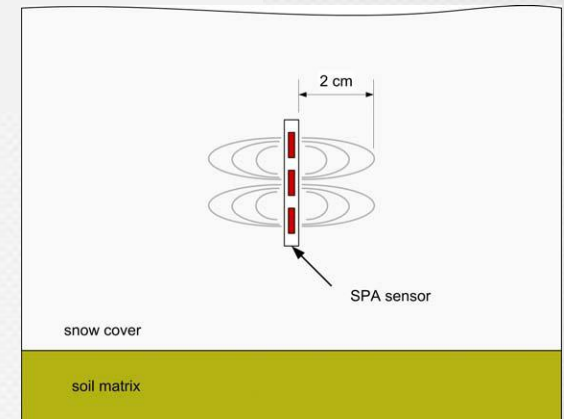


❄ Automatic SnoTel and  
snow pillows (2000's)

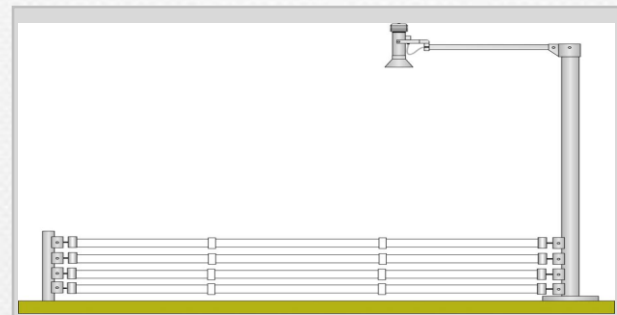


# SnowPack Analyser (SPA)

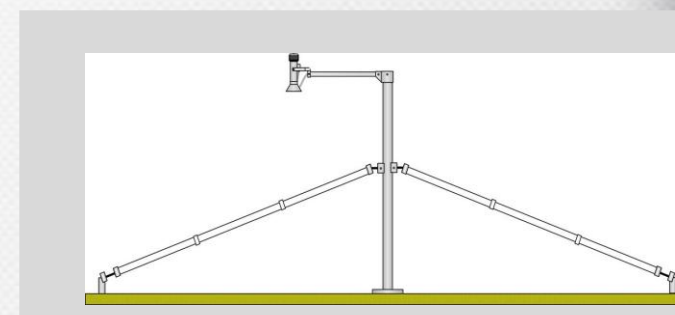
- ❄ Three snow components: ice, water, air (dielectric const.)
- ❄ Measure complex impedance at two freq. along flat strap
- ❄ Determine volume contents of components



Combined Assembly



Profile Assembly



Areal Assembly



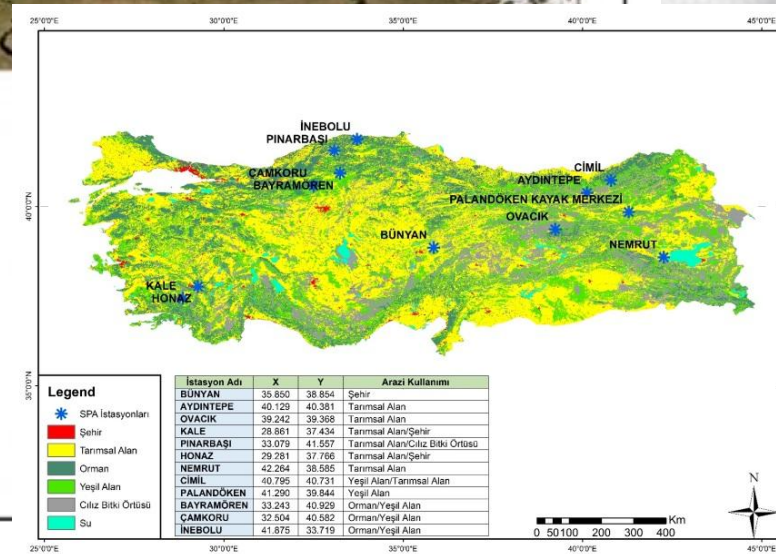
# SPA Stations in Turkey

11 SPA stations are set up in Turkey before 2015 snow season

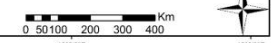
SPA stations in Turkey



Station	Drainage Basin	Elevation (m)
Palandöken	Fırat	2610
Nemrut	Van Gölü	2550
Cimil	D. Karadeniz	2072
Aydintepe	Çoruh	1597
Bayramören	Kızılırmak	1450
Çamkoru	Sakarya	1402
Bünyan	Kızılırmak	1335
Ovacık	Fırat	1280
Kale	B. Menderes	1190
Pınarbaşı	B. Karadeniz	1010
İnebolu	B. Karadeniz	965
Honaz	B. Menderes	492



İstasyon Adı	X	Y	Arazi Kullanımı
BUNYAN	35.850	38.854	Şehir
AYDINTEPE	40.129	40.381	Tarımsal Alan
OVACIK	39.242	39.368	Tarımsal Alan
KALE	28.861	37.434	Tarımsal Alan/Şehir
PINARBAŞI	33.079	41.957	Tarımsal Alan/Çiftlik Bittü Ormanı
HONAZ	29.281	37.766	Tarımsal Alan/Şehir
NEMRUT	42.264	38.585	Tarımsal Alan
CİMİL	40.795	40.731	Yeşil Alan/Tarımsal Alan
PALANDÖKEN	41.290	38.844	Yeşil Alan
BAYRAMÖREN	33.243	40.929	Orman/Yeşil Alan
ÇAMKORU	32.504	40.582	Orman/Yeşil Alan
İNEBOLU	41.875	33.719	Orman/Yeşil Alan

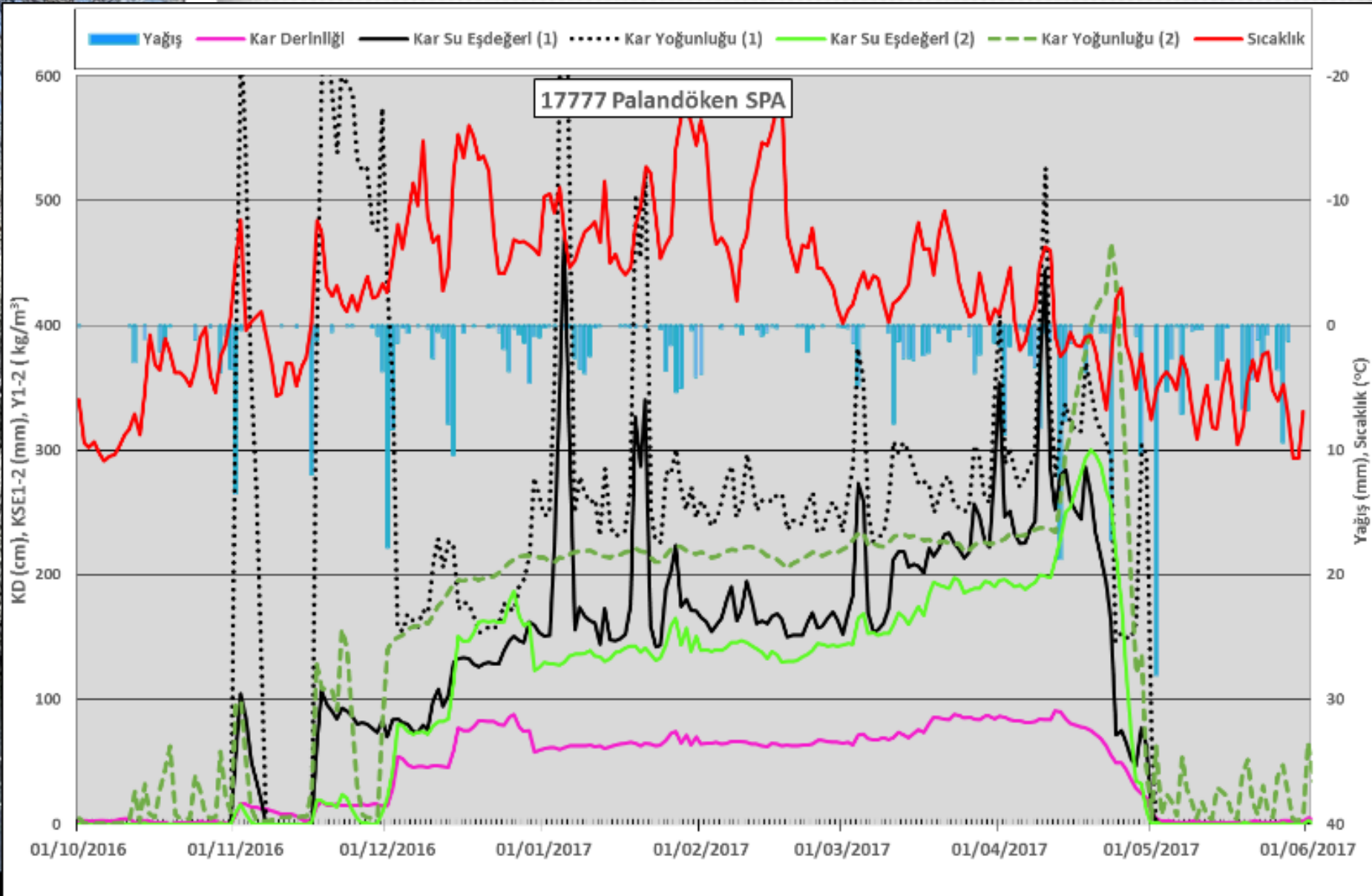


# SPA Stations in Turkey



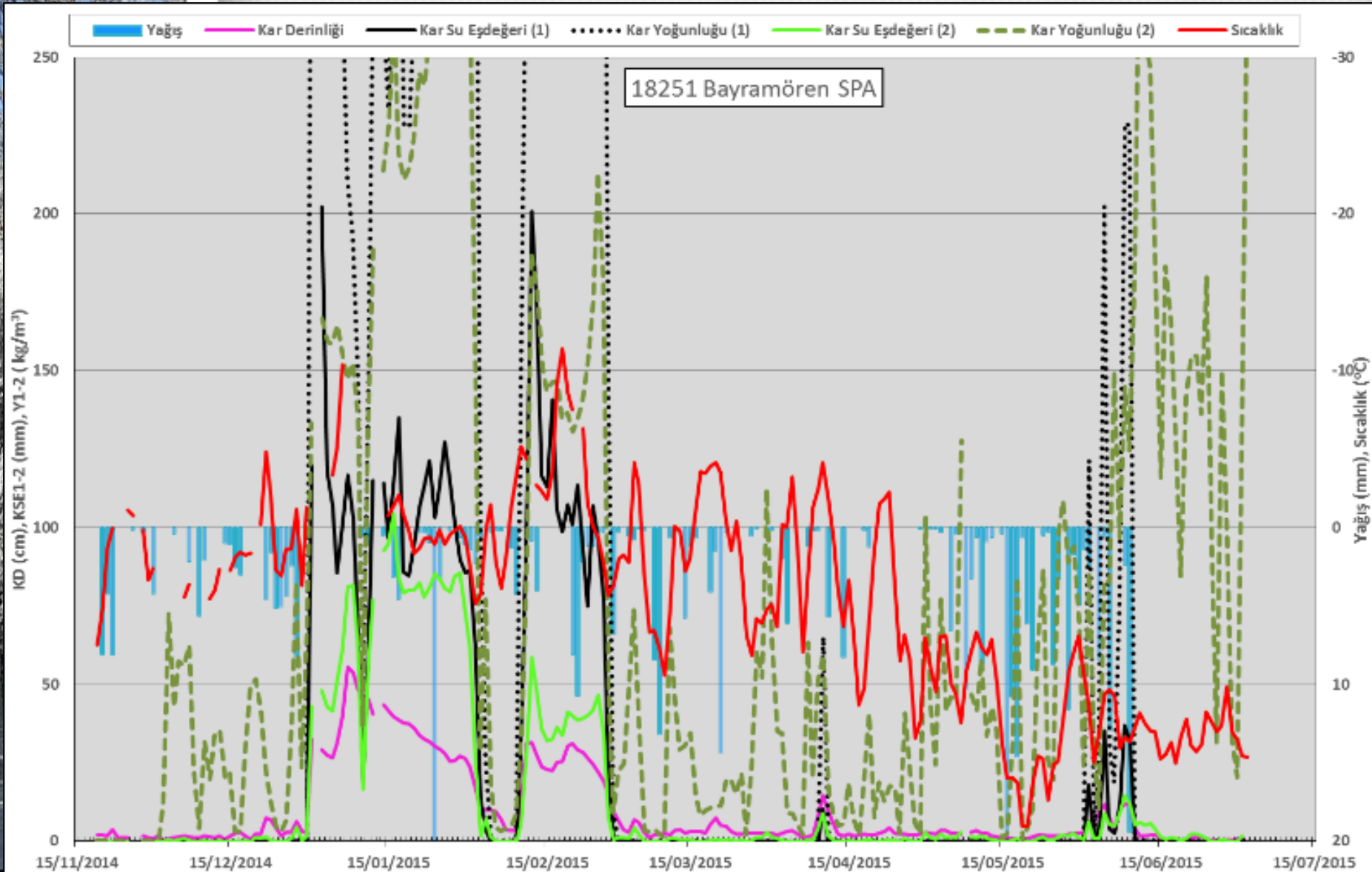


# SPA Measurement Examples in Turkey

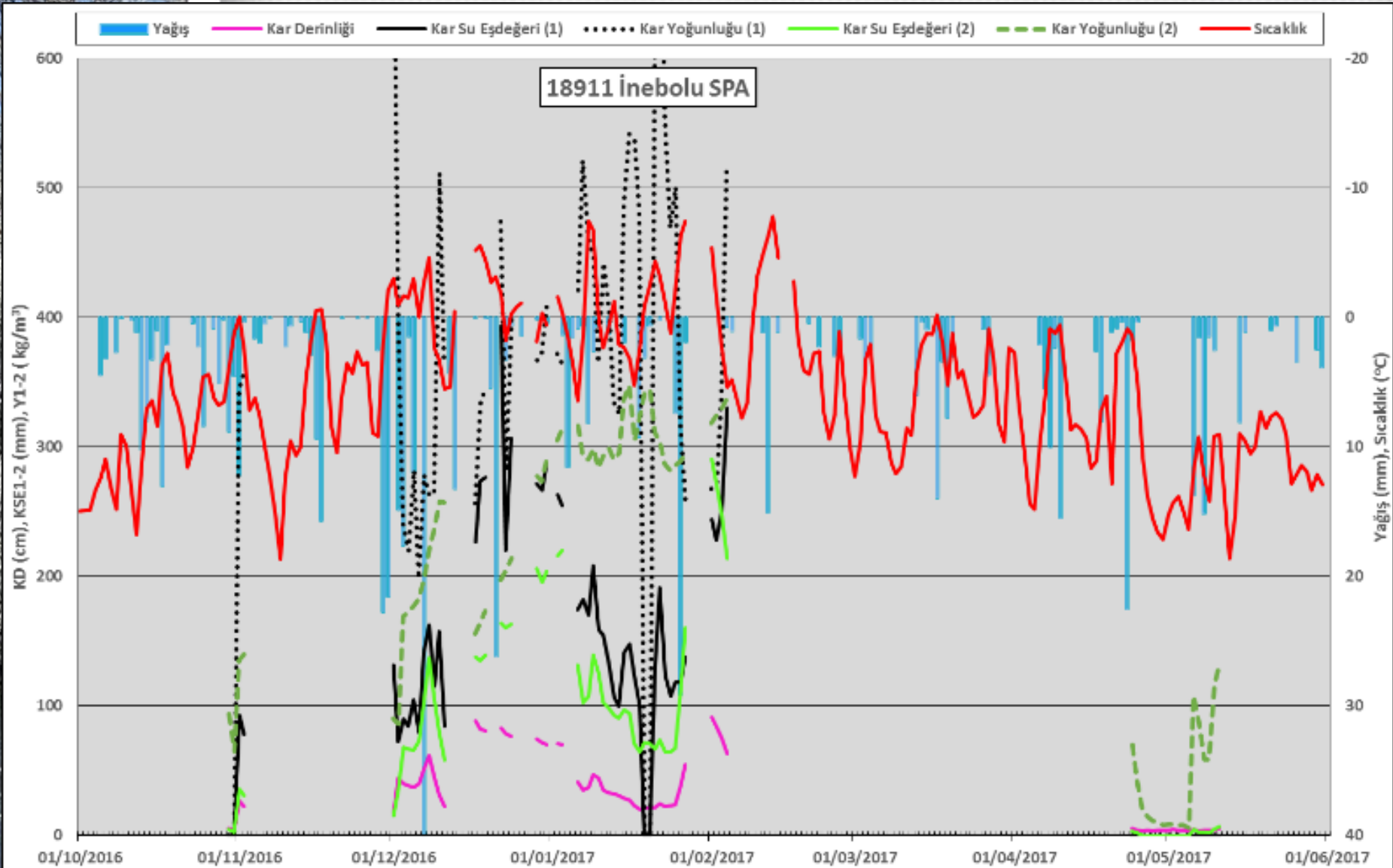




# SPA Measurement Examples in Turkey

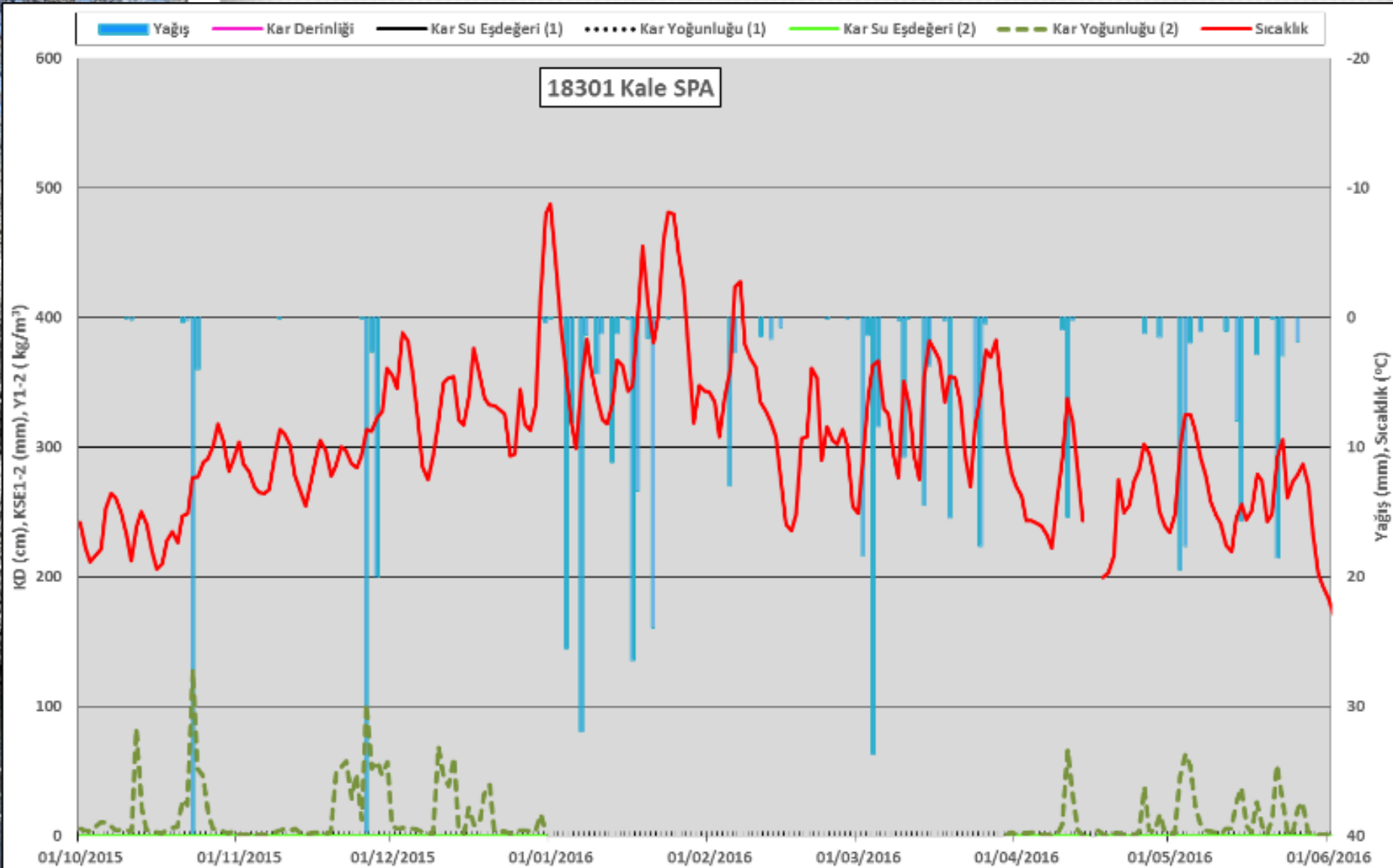


# SPA Measurement Examples in Turkey

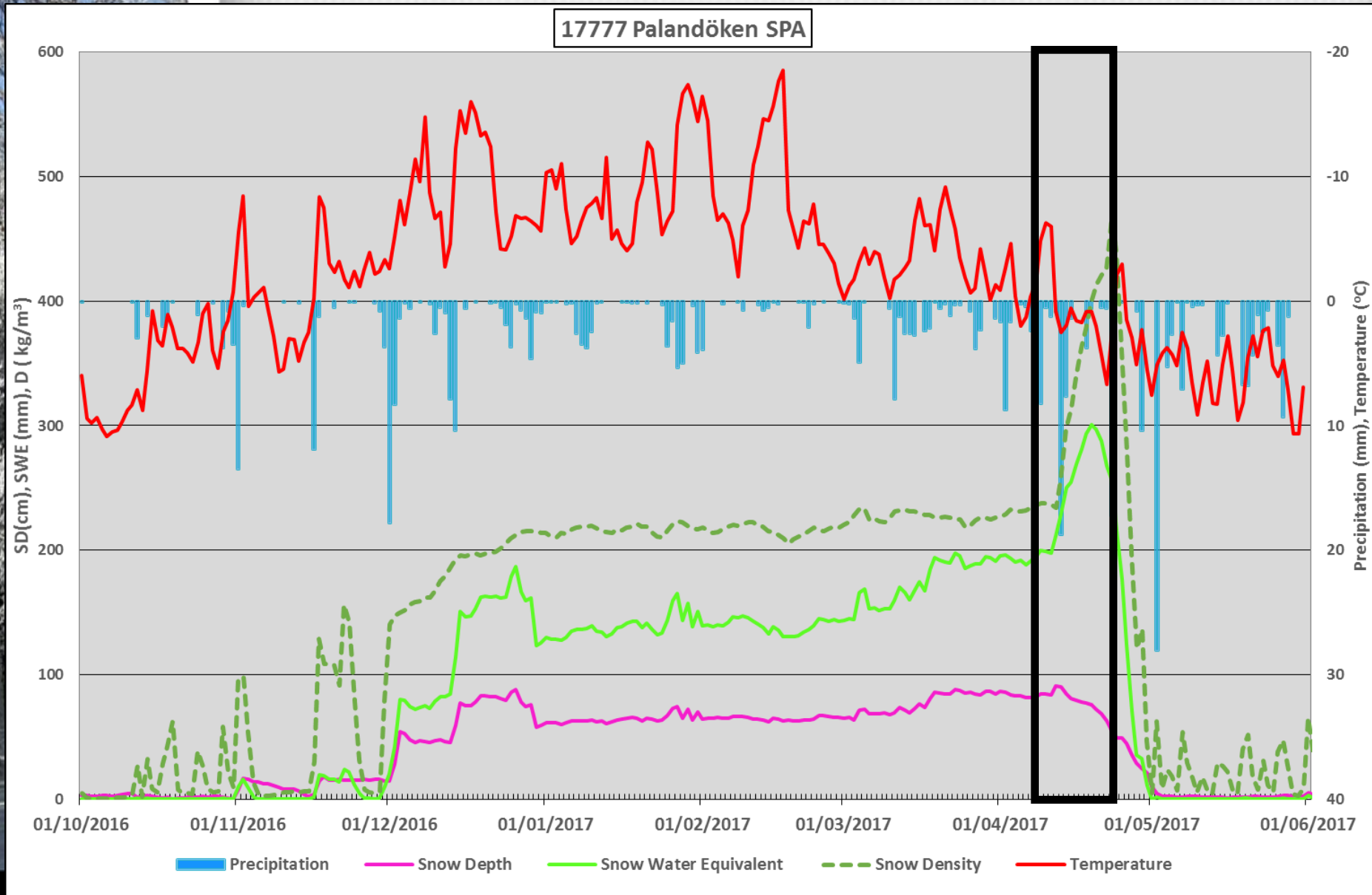




# SPA Measurement Examples in Turkey



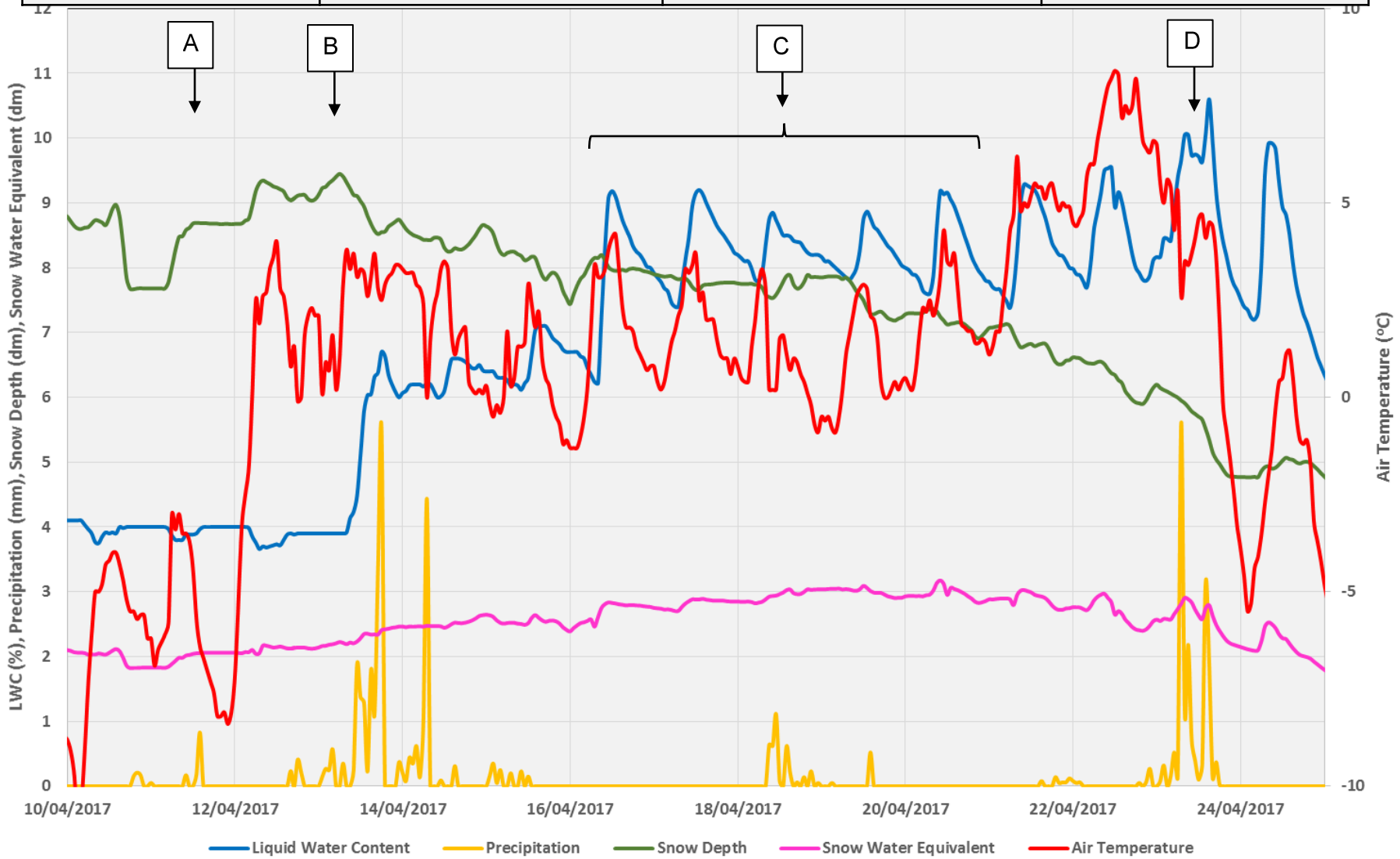
# SPA Measurement Examples in Turkey



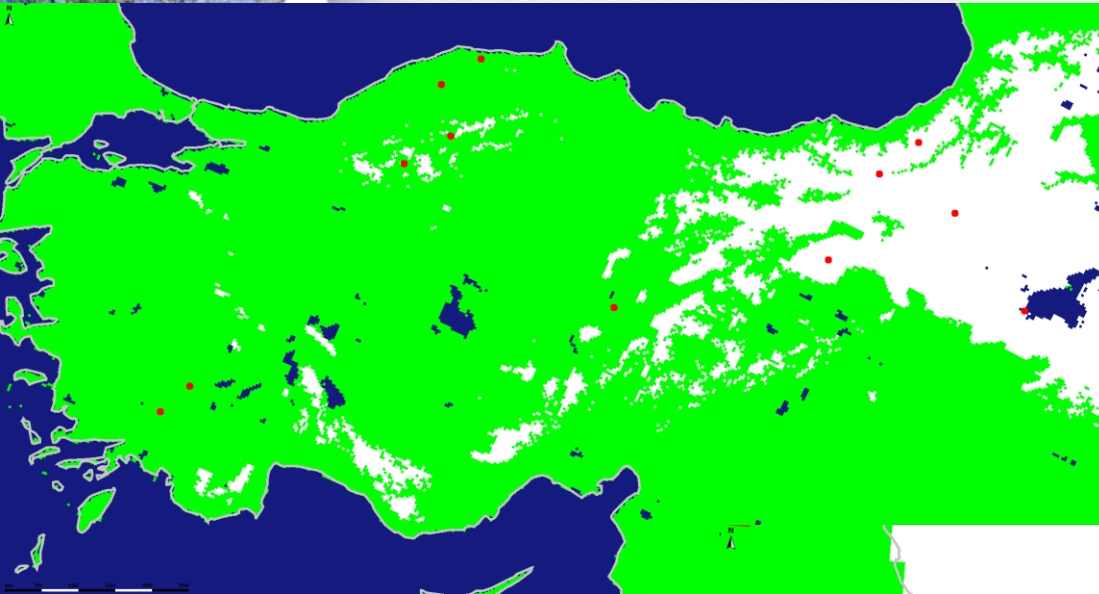


# SPA Measurement Examples in Turkey

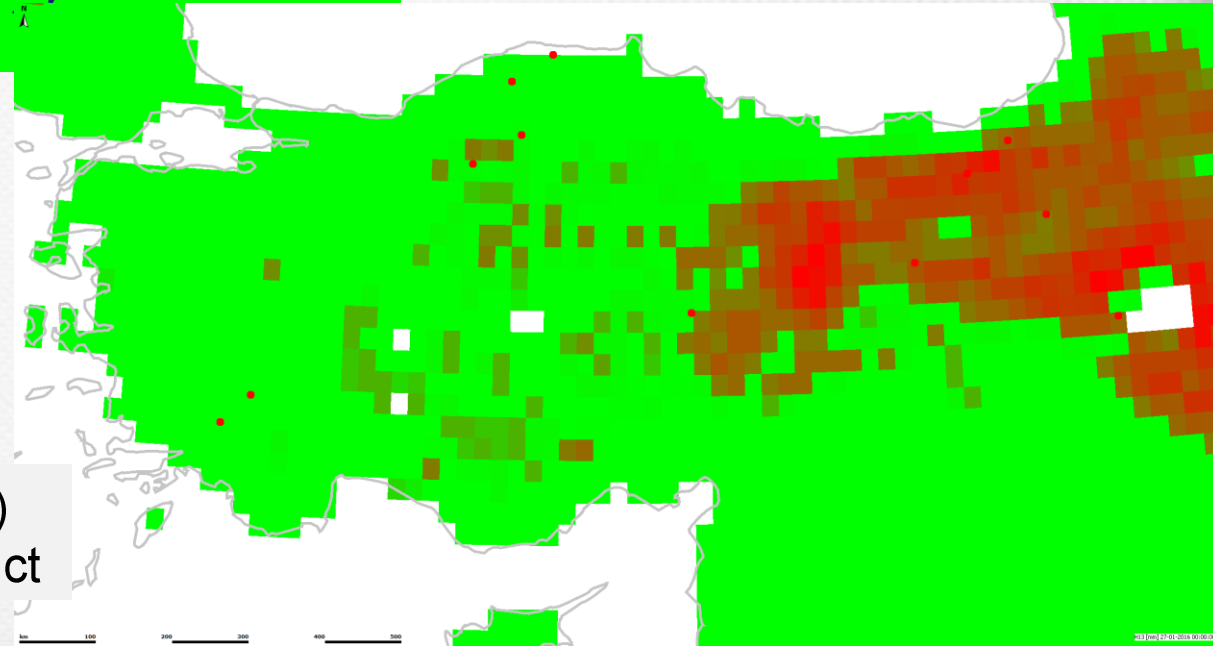
Point A	Point B	Point C	Point D
<ul style="list-style-type: none"> <li>Air Temp. <math>&lt; 0^{\circ}\text{C}</math></li> <li>Constant LWC, SWE, SD</li> </ul>	<ul style="list-style-type: none"> <li>Air Temp. <math>&gt; 0^{\circ}\text{C}</math></li> <li>Rain-on-snow</li> <li>Increase of LWC <math>\sim 6-7\%</math></li> </ul>	<ul style="list-style-type: none"> <li>Diurnal cycle for LWC <math>\sim 7-9\%</math></li> <li>SD <math>\downarrow</math> and SWE <math>\uparrow</math></li> </ul>	<ul style="list-style-type: none"> <li>Max. LWC <math>\sim 10\%</math></li> <li>SWE <math>\downarrow</math> and snowmelt</li> </ul>



# Satellite Remote Sensing



Snow Covered Area (SCA)  
using NOAA IMS product



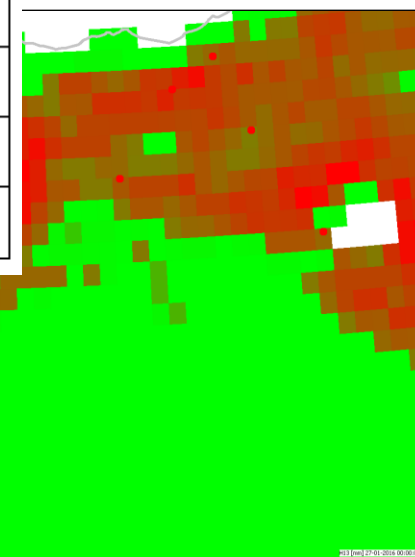
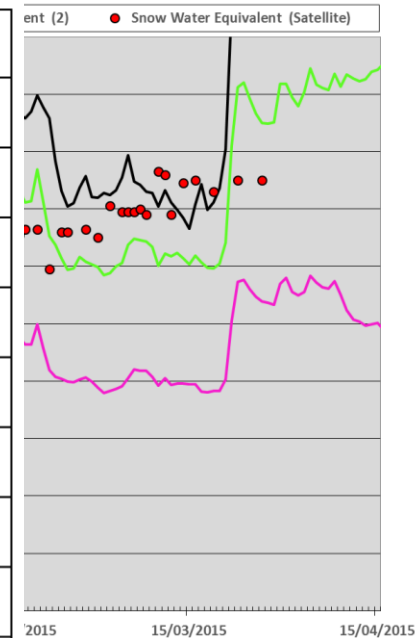
Snow Water Equivalent (SWE)  
using EUMETSAT H-SAF product





# Snow Water Equivalent (SWE)

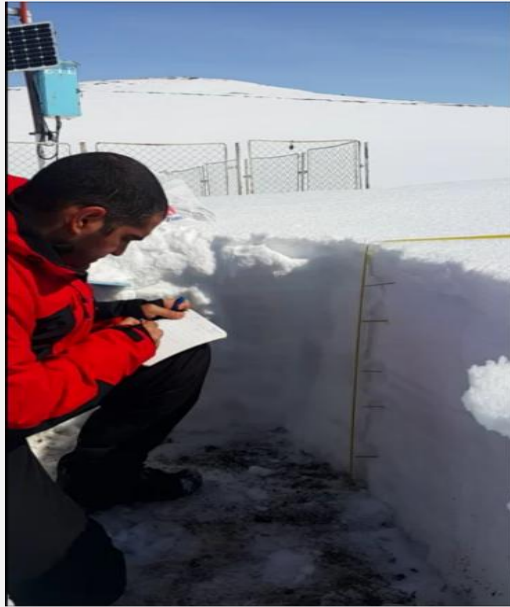
	Elev (m)	Obs. No.	RMSE (mm)		MAE (mm)	
			SWE-1	SWE-2	SWE-1	SWE-2
<b>Palandöken</b>	2610	59	30.0	57.3	20.4	37.5
<b>Nemrut</b>	2550	19	484.0	552.4	429.0	533.2
<b>Cimil</b>	2072	46	78.9	95.7	73.4	88.7
<b>Aydıntepe</b>	1597	28	103.0	113.2	96.6	113.2
<b>Bayramören</b>	1450	36	99.5	70.4	91.3	66.1
<b>Çamkoru</b>	1402	10	40.7	62.1	33.3	59.6
<b>Bünyan</b>	1335	27	84.7	83.1	83.1	81.4
<b>Ovacık</b>	1280	11	123.5	129.4	121.5	111.1
<b>Kale</b>	1190	0	0.0	0.0	0.0	0.0
<b>Pınarbaşı</b>	1010	0	0.0	0.0	0.0	0.0
<b>Honaz</b>	492	0	0.0	0.0	0.0	0.0



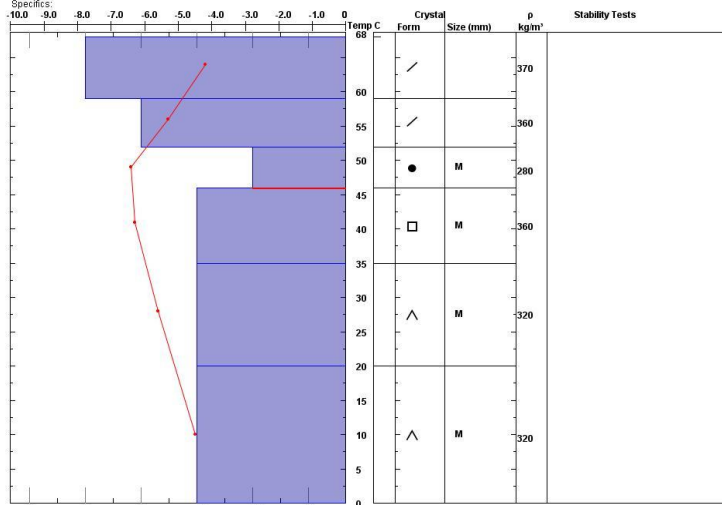
Snow Water Equivalent (SWE)  
using EUMETSAT H-SAF product



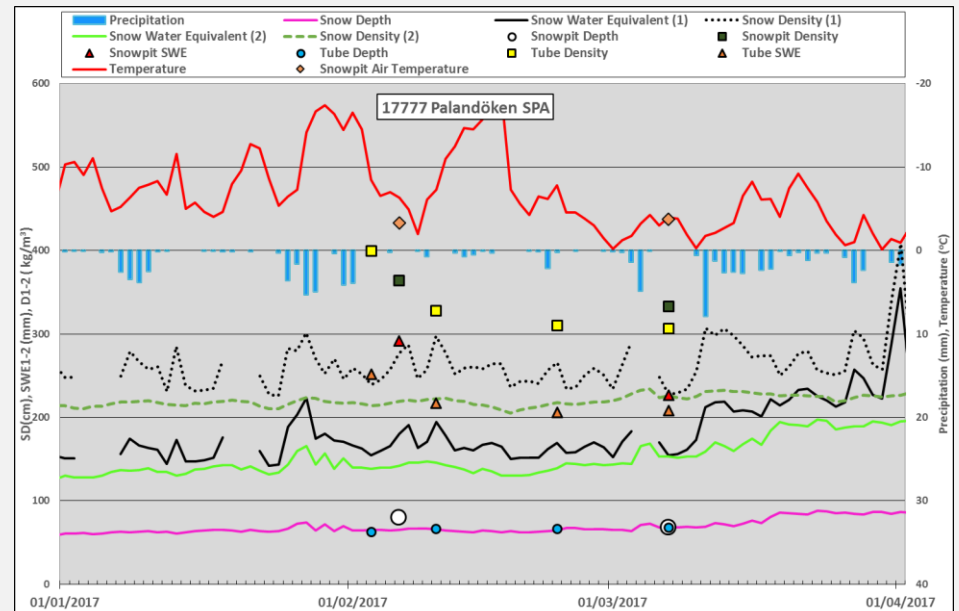
# Manual Snow Measurements



Snow Pit Profile  
**Palandöken**  
 , other  
 Elevation (m) 2610  
 Aspect:  
 Specifics:  
 Observer: **Cansaran Ertas**  
 Tue Mar 07 16:30:00 EET 2017  
 Co-ord: **N W**  
 Slope:  
 Wind loading:  
 Stability on similar slopes:  
 Air Temperature: **-3.7 C**  
 Sky Cover: **Clear**  
 Precipitation: **None**  
 Wind: **Light Breeze**  
 HS08  
 Stability Test Notes:  
 Layer notes:  
**46.52: Problematic Layer**



Notes: Palandöken 2610 m near SPA Station



# Conclusions

- ❄ SPA stations can provide important snow component data in real-time during a snow season (maintenance)
- ❄ SPA data can be utilized in snow or hydrologic modeling
- ❄ Manual ground measurements (tube, pit) can assist SPA data
- ❄ Different assembly should be setup for shallow snow (<50cm)
- ❄ 6 SPA stations will be relocated for 2018 snow season  
(due to urban and water effect, altitude, representativity)







Thank You

# SPA Relocation

