ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

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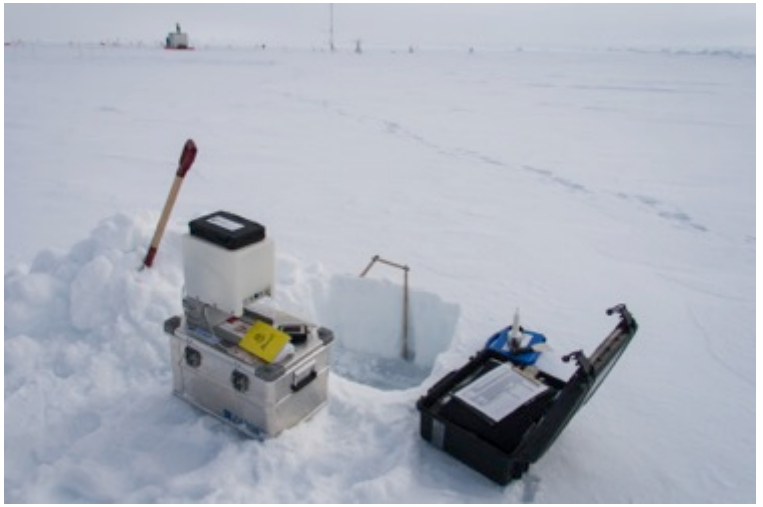
Snow depth on Antarctic sea ice from autonomous measurements

HELMHOLTZ GEMEINSCHAFT

Snow Rules !

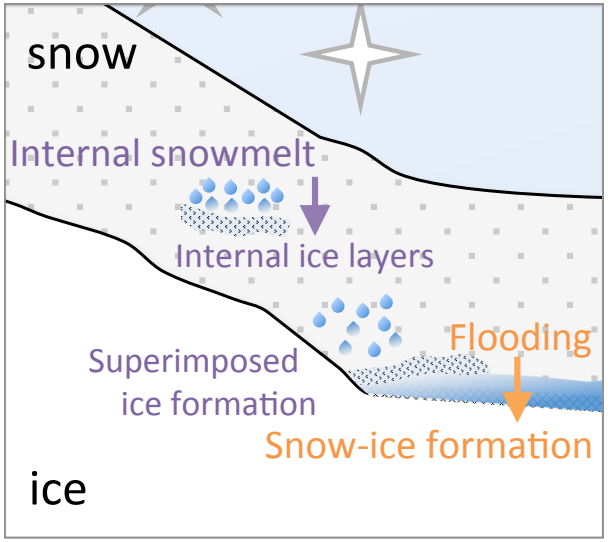
Direct impacts

- Thermodynamics
- Energy and mass budget
- Remote sensing signatures
- Fresh water budgets



Indirect effects

- Sea ice thickness measurements
- Total thickness measurements (EM techniques)
- Interpretation of surface conditions
- Model and remote sensing validation and development



Need for better snow depth and properties data

Challenges for Seasonality

Arctic

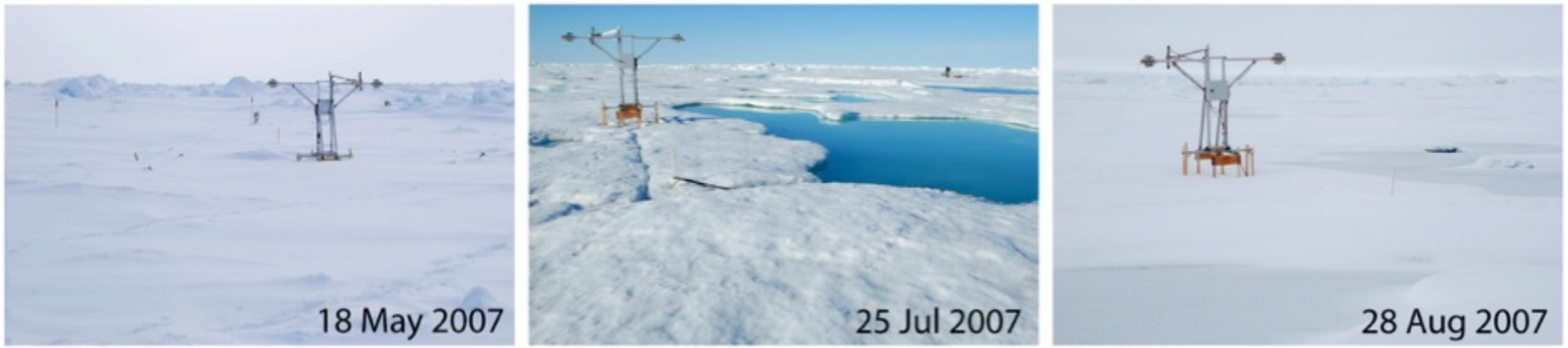
- Combining various campaigns at different times for snow climatology (Warren et al., 1999)
- Few multi-seasonal studies, e.g., SHEBA, Tara, N-ICE, NP-stations

Antarctic

- No climatology
- ASPeCt data set contains snow depth information
- Snow depth product from passive microwave data (Markus & Cavalieri, 1998)

Essential need for time series data

Seasonal change of (snow) surface properties on Arctic sea ice during Tara in 2007.



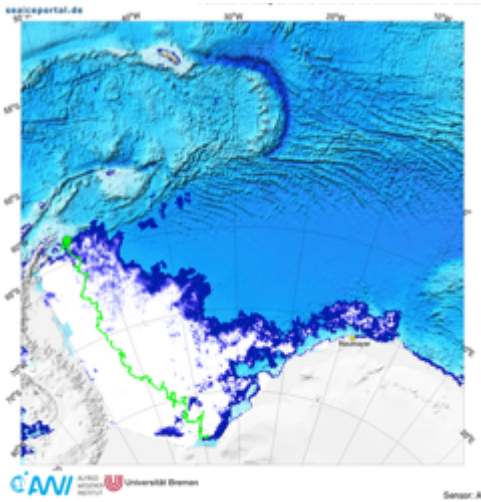
Snow Buoy

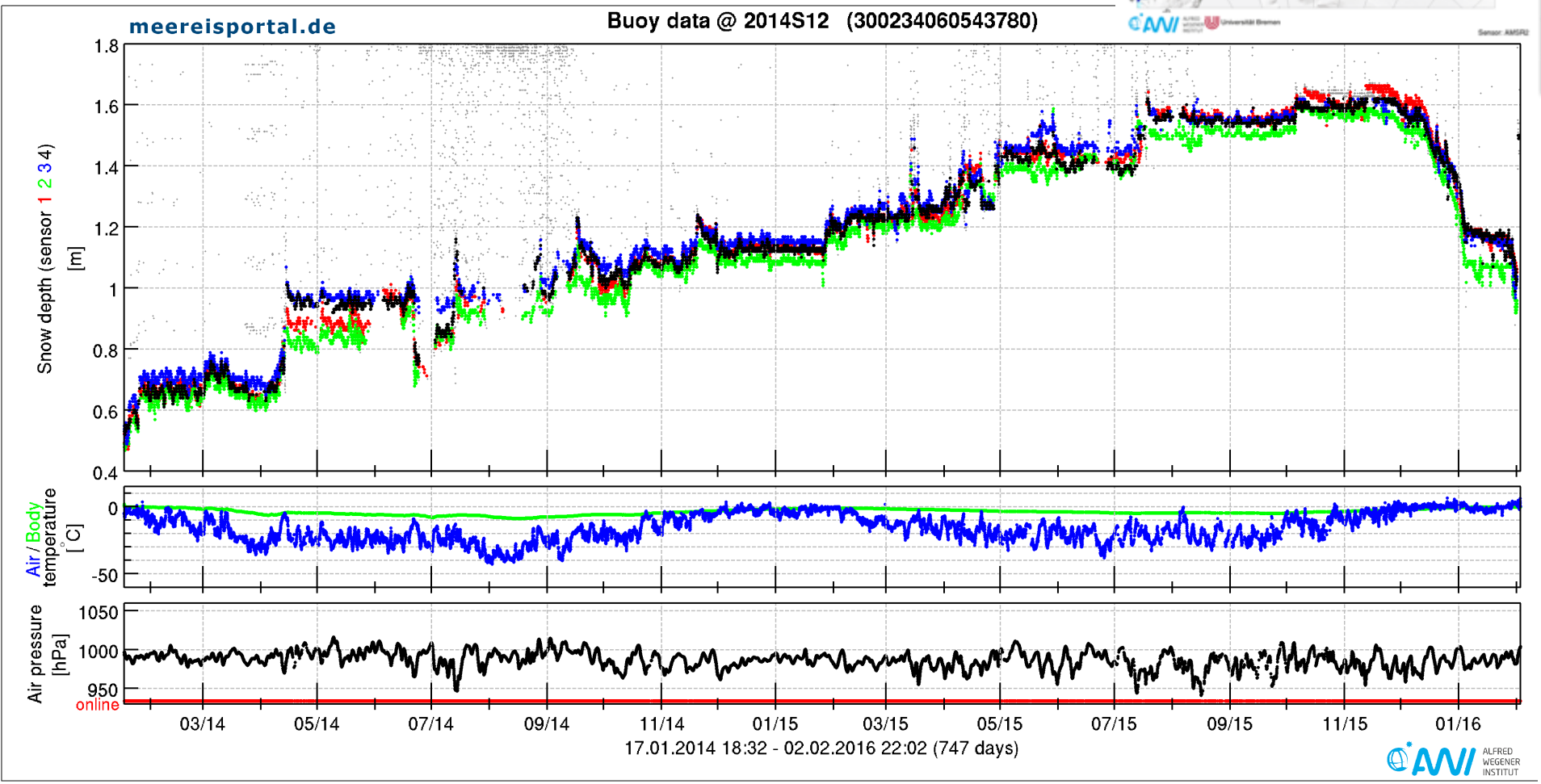
- Parameters
  - **4 x snow depth** (variability & reliability)
  - **Air temperature**, body (snow/ice) temperature
  - **Barometric Pressure**
  - GPS, as all autonomous units
- Data transmission: Iridium
- Data provision into GTS
- Power supply (batteries > 1 year)
- Now: Version 3 (development since 2012)

Parameter	Sensor	Accuracy	Interval
Distance to Surface	Max Botix, Sonar MB7092	1 cm	7 / hour
Air Temparature	YSI, 44032	0.5 °C	7 / hour
Surface Temperature	YSI, 44032	0.5°C	20 / hour
Barometric Pressure	Vaisala, PTB 110	1 mbar	20 / hour
Data transfer	Iridium 9602 SBD		every 3 hours
GPS Position	Jupiter 32xLP module & antenna	10 m	every 3 hours
Power Supply	Lithium battery (15V)		7 / hour

Data Example 2014S12

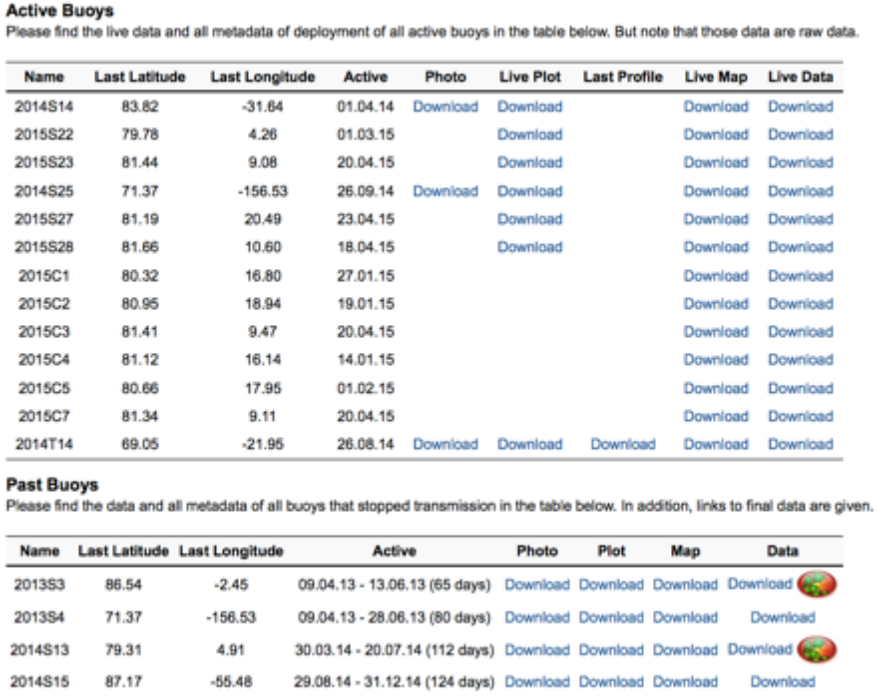
- Weddell Sea drift
  from Jan 2014 to Feb 2016 (> 2 years)





Data Portal and Archive

http://data.seaiceportal.de



Active Buoys

Please find the live data and all metadata of deployment of all active buoys in the table below. But note that those data are raw data.

Name	Last Latitude	Last Longitude	Active	Photo	Live Plot	Last Profile	Live Map	Live Data
2014S14	83.82	-31.64	01.04.14	Download	Download		Download	Download
2015S22	79.78	4.26	01.03.15		Download		Download	Download
2015S23	81.44	9.08	20.04.15		Download		Download	Download
2014S25	71.37	-156.53	26.09.14	Download	Download		Download	Download
2015S27	81.19	20.49	23.04.15		Download		Download	Download
2015S28	81.66	10.60	18.04.15		Download		Download	Download
2015C1	80.32	16.80	27.01.15				Download	Download
2015C2	80.95	18.94	19.01.15				Download	Download
2015C3	81.41	9.47	20.04.15				Download	Download
2015C4	81.12	16.14	14.01.15				Download	Download
2015C5	80.66	17.95	01.02.15				Download	Download
2015C7	81.34	9.11	20.04.15				Download	Download
2014T14	69.05	-21.95	26.08.14	Download	Download	Download	Download	Download

Past Buoys

Please find the data and all metadata of all buoys that stopped transmission in the table below. In addition, links to final data are given.

Name	Last Latitude	Last Longitude	Active	Photo	Plot	Map	Data
2013S3	86.54	-2.45	09.04.13 - 13.06.13 (65 days)	Download	Download	Download	Download
2013S4	71.37	-156.53	09.04.13 - 28.06.13 (80 days)	Download	Download	Download	Download
2014S13	79.31	4.91	30.03.14 - 20.07.14 (112 days)	Download	Download	Download	Download
2014S15	87.17	-55.48	29.08.14 - 31.12.14 (124 days)	Download	Download	Download	Download

- Buoy tracks and data (daily)
- Meta data and deployment info
- Active and past buoys

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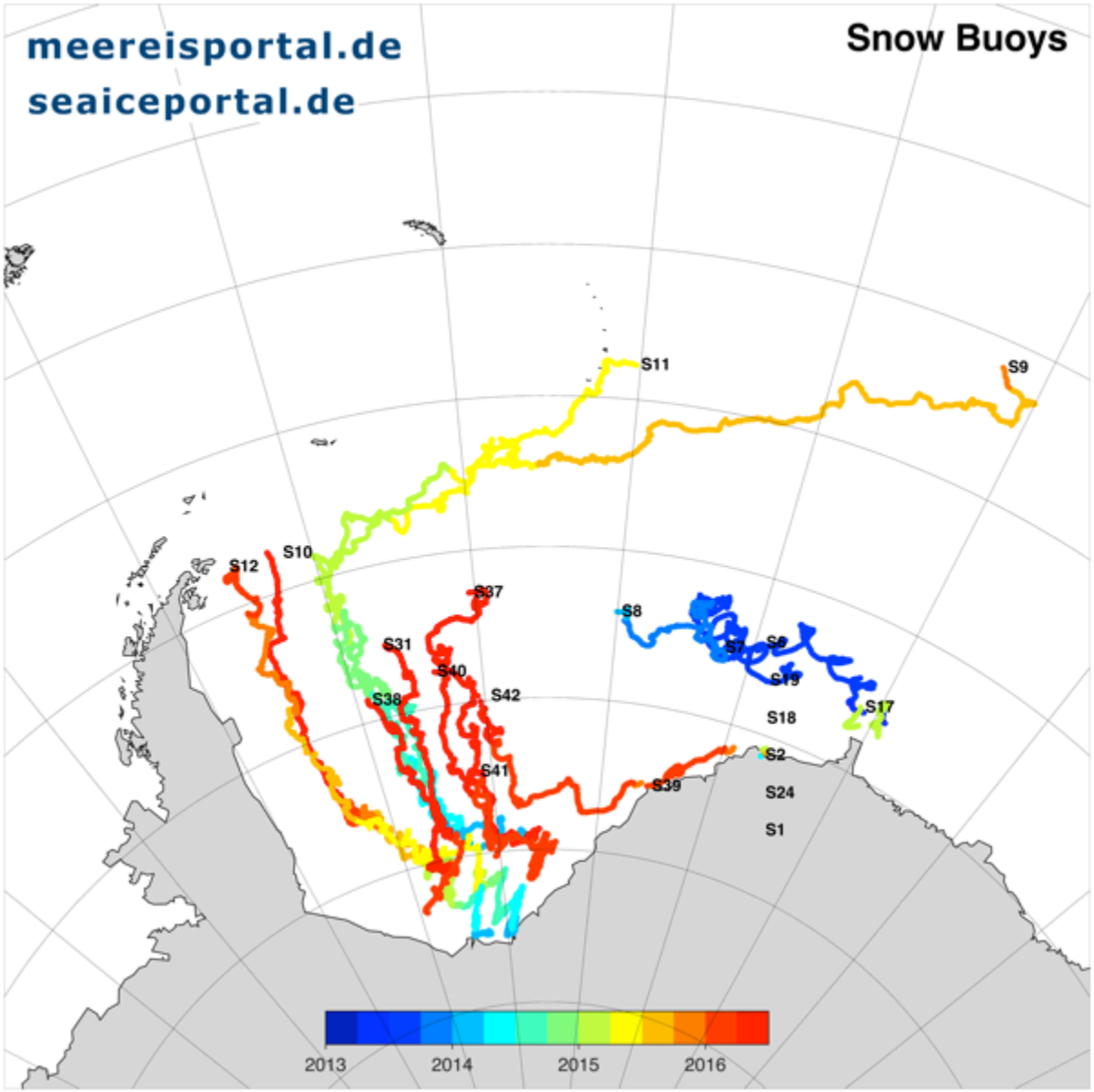
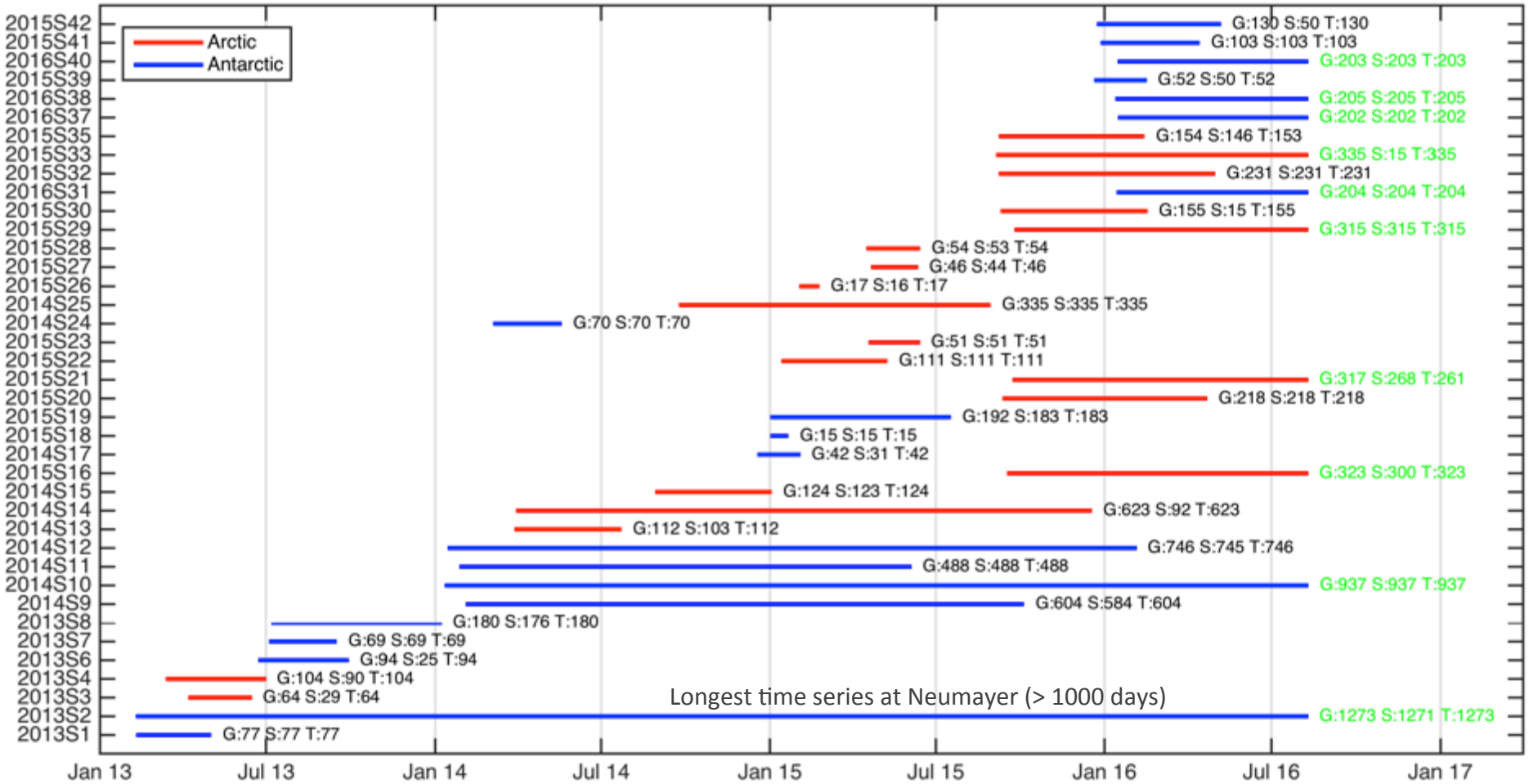
Antarctic Drift Pathes



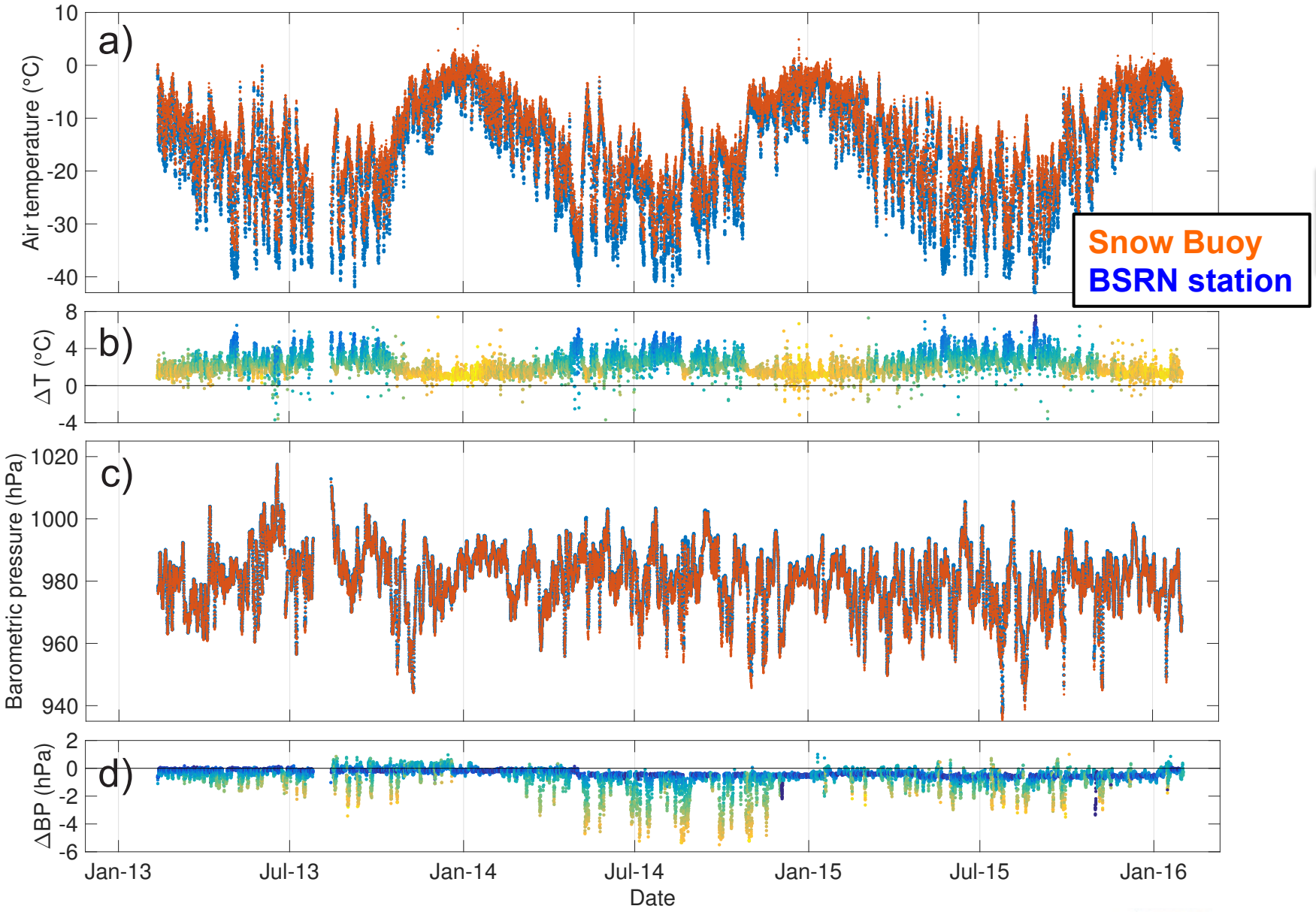
Lifetime Statistics



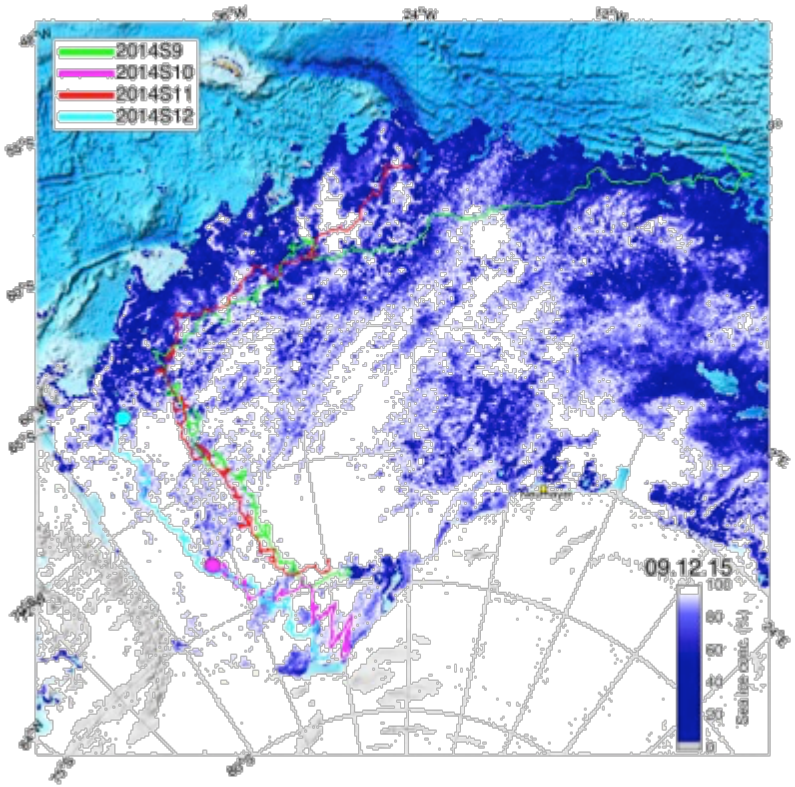
Green = 10 units currently reporting

Status 18 Apr 2016

Comparison to Neumayer III Station

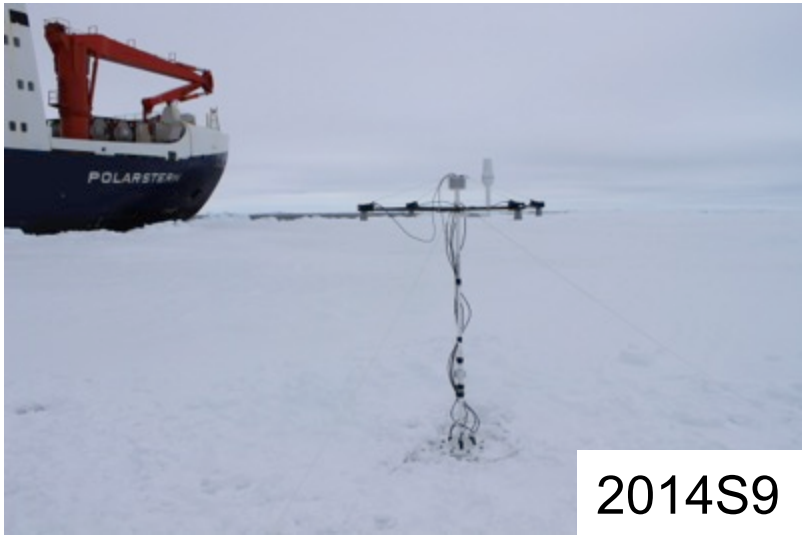


Weddell Sea Snow Buoys in 2014/15



Buoy	Ice	zi (m)	fb (m)	zs (m)
2014S9	FYI	1.05	0.08	0.08
2014S10	FYI	1.32	0.12	0.03
2014S11	FYI	1.61	0.29	0.29
2014S12	FYI	1.65	0.13	0.03

- S9 and S11 (Pair 1)
- S10 and S12 (Pair 2)
- All deployments Jan/Feb 2014



2014S9

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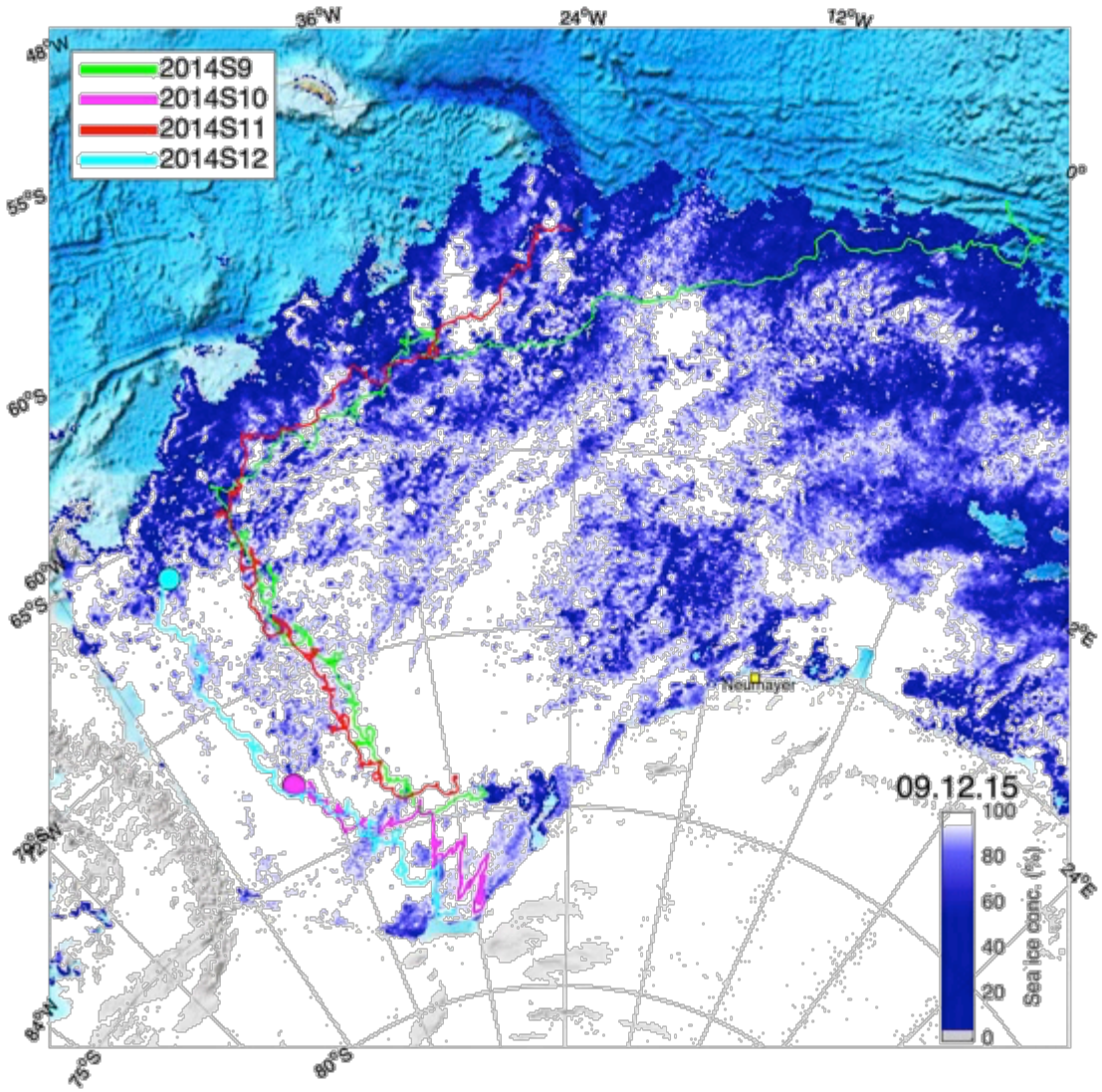
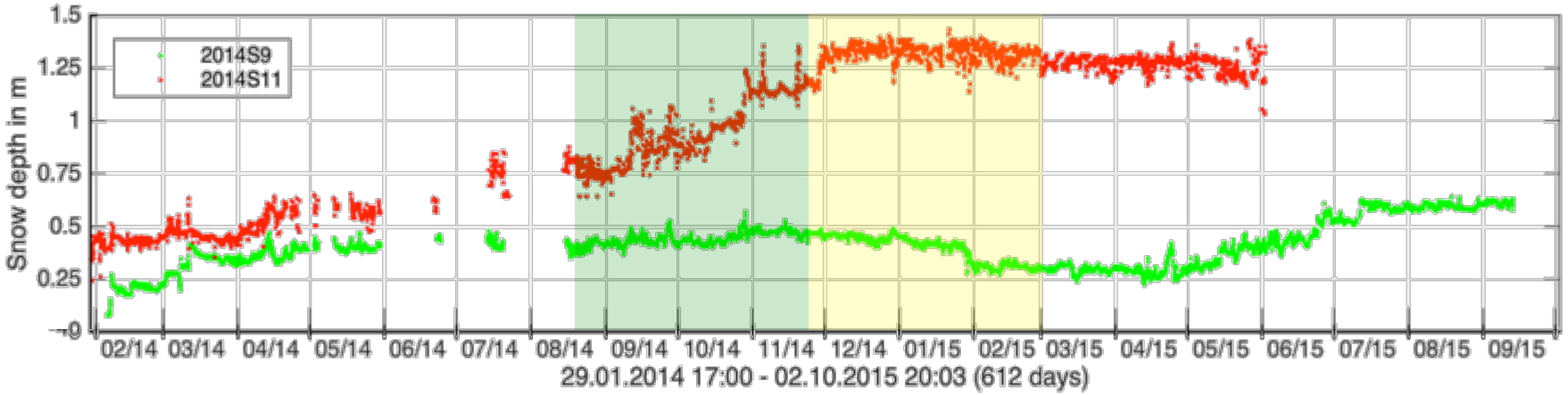
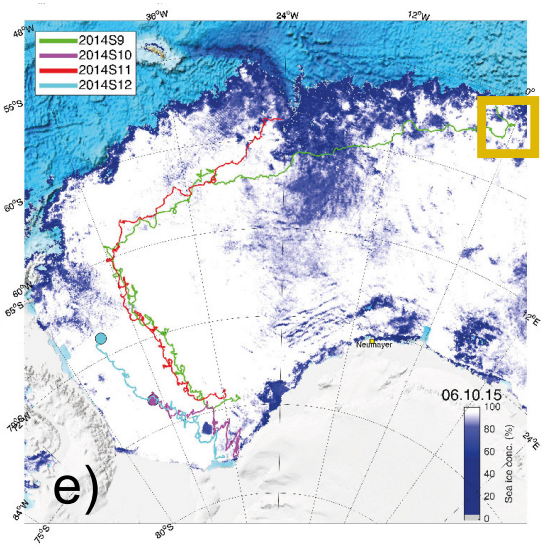
Animated Drift



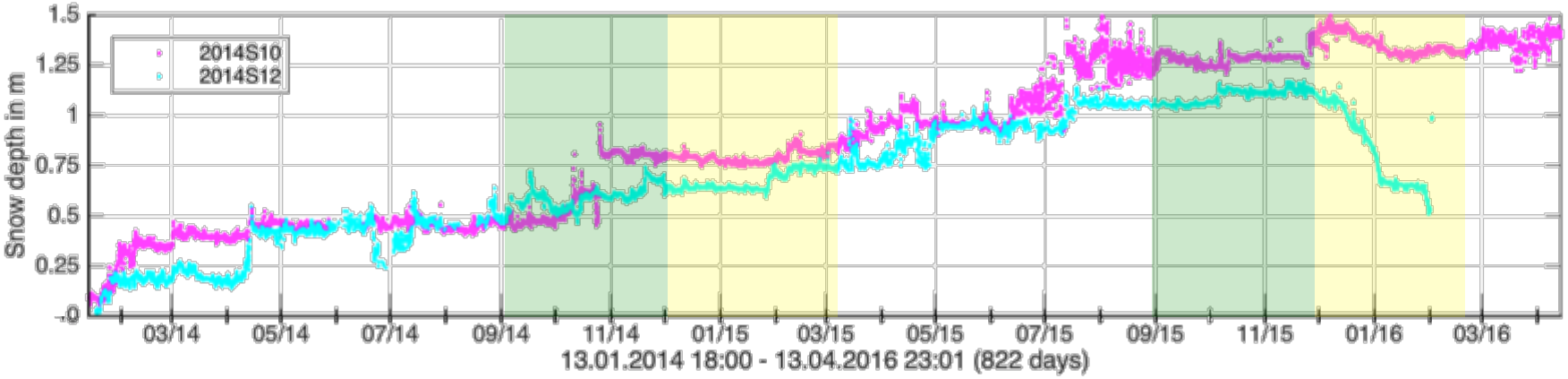
Pair 1 = Close Pair (North)



- **Spring 2014**
  - S11: Accumulation 60 cm in spring 2014
  - S9: Constant in spring
- **Summer 2014/15**
  - S11: Some compaction (melt): ~10 cm
  - S9: Significant compaction (melt) by 20 cm
- **Annual budget** (Feb 2014 to Feb 2015)
  - S11: + 90 cm
  - S9: + 20 cm



Pair 2 = Distant Pair (South)



Spring 2014

Consistent increase of 20 to 35 cm

Spring 2015

Little change

Summer 2014/15

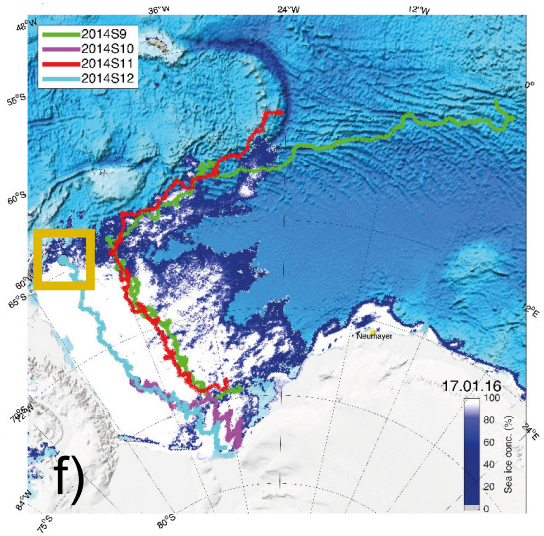
No compaction /melt

S12: Summer increase of 15 cm

Summer 2015/16

Strong melt at ice edge

Temporary compaction and melt



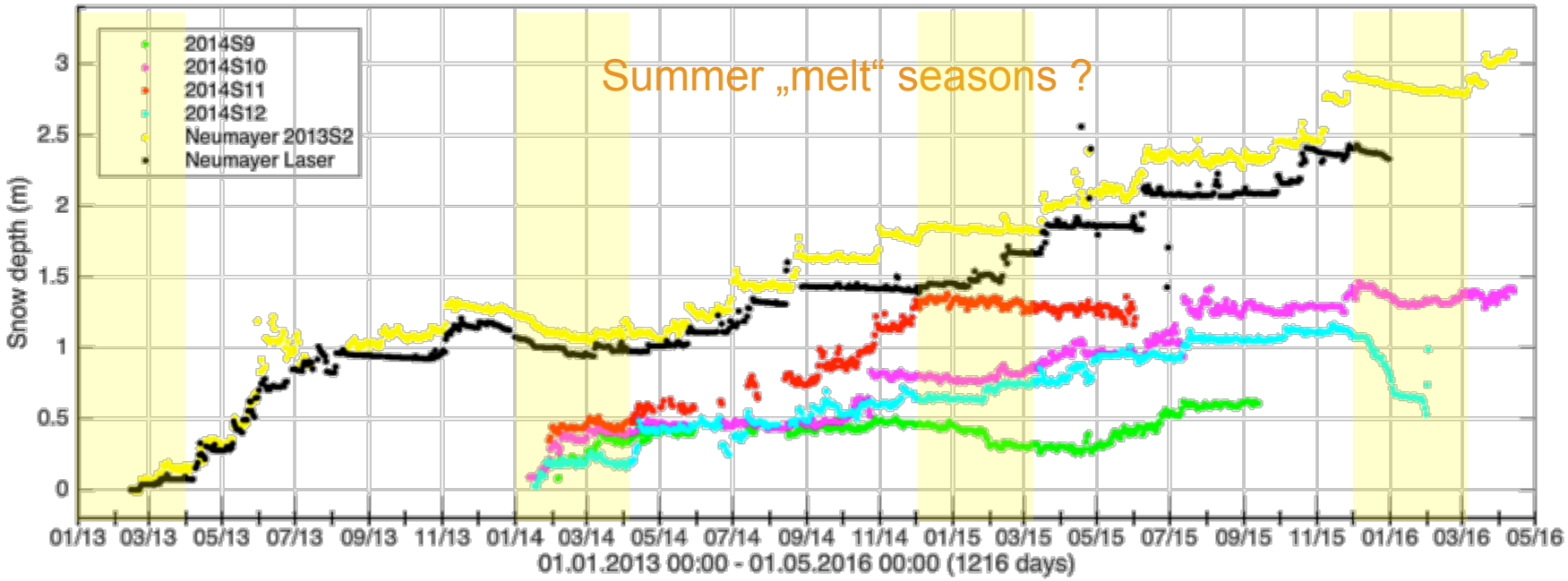
Annual budget 2014/15

Increase by 75 cm

Annual budget 2015/16

Increase by 50 cm

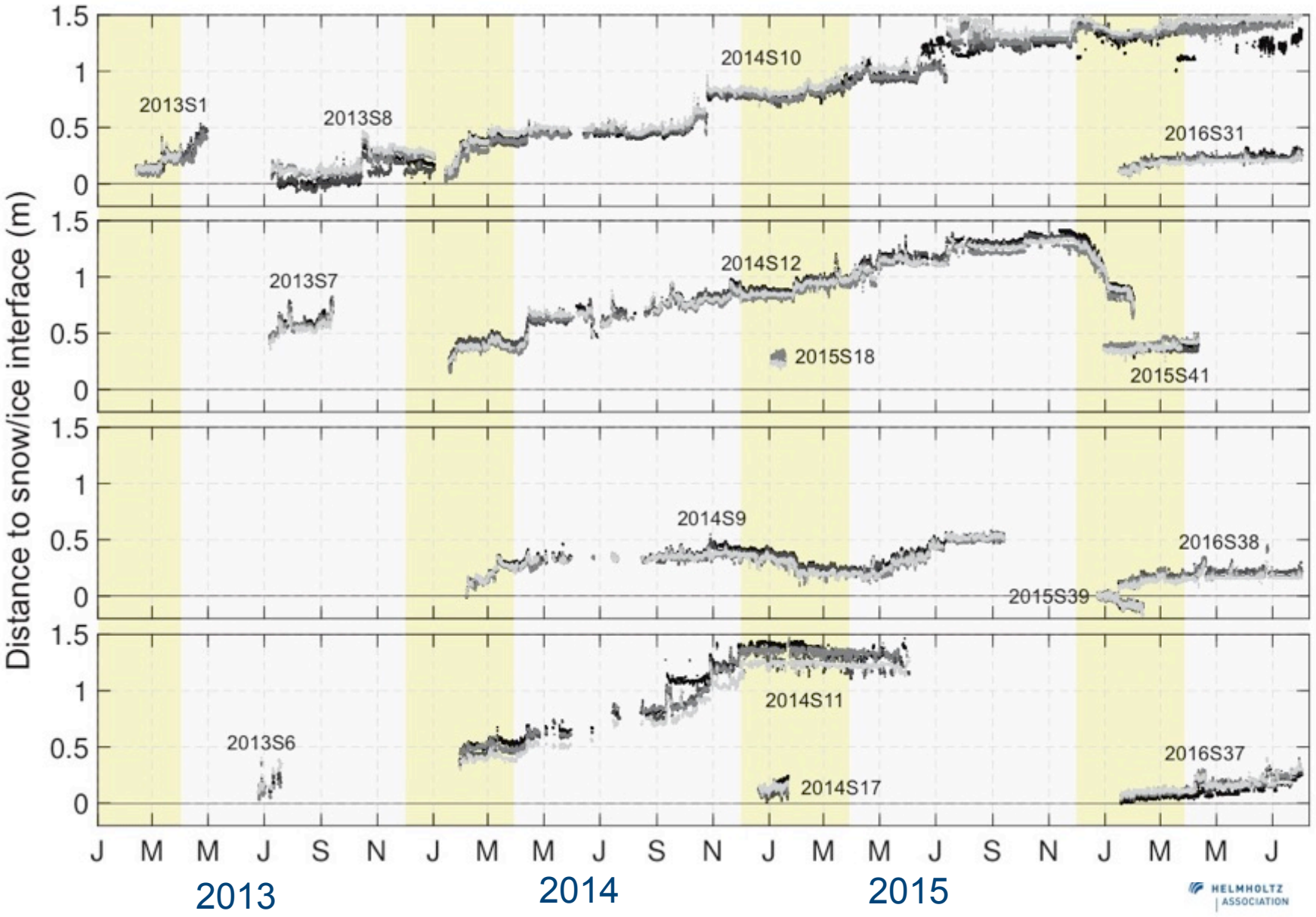
Seasonality (Drift + Neumayer)



Seasonal snow depth evolution

- Annual accumulation 20 to 90 cm
- Event driven, partly long times of constant snow depth
- No consistent summer decrease (melt)
- Annual variability at Neumayer:
  Decrease in summer 2014 & 2016, but not in 2015

All Antarctic Buoys



Summary & Outlook

Snow buoys advance seasonal understanding of snow cover on sea ice and contribute to distributed networks

Weddell Sea net accumulation of 20 to 90 cm

- No summer melt in southern Weddell Sea
- No complete snow melt in any data set
- Strong melt along ice edge

Additional results from Arctic buoys

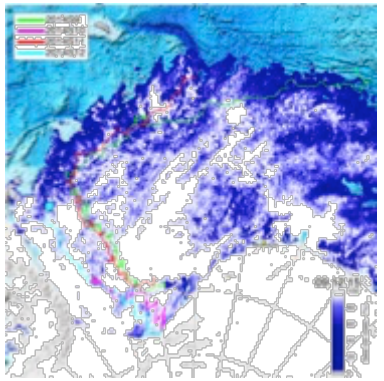
- Air temperature effects: warm winter 2015/16
- Impacts on sea ice thickness / mass balance

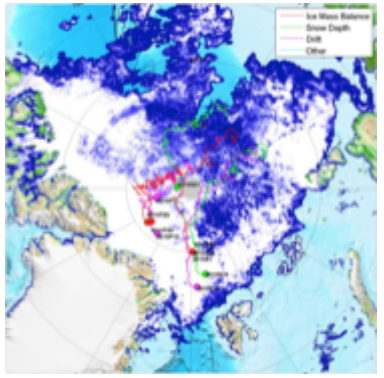
Variability on different **temporal and regional scales**

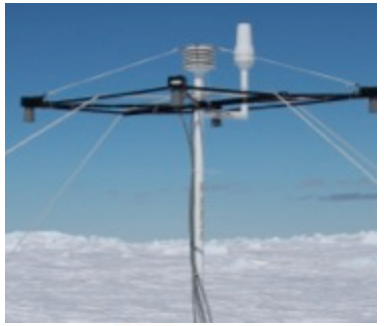
=> More time series needed to develop full seasonality

Further needs

- **Joined analyses** with satellite and model results
- Community effort of deployments and analysis







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