Climate Change

Microwave temperature sounder fundamental climate data records for climate applications

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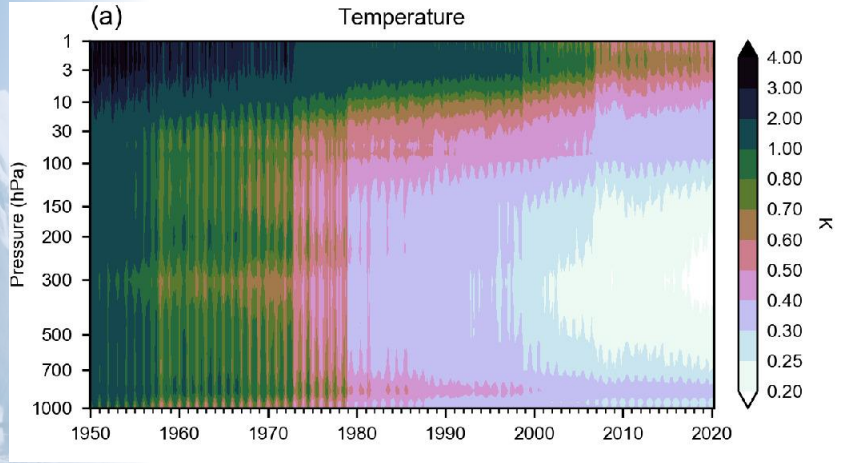
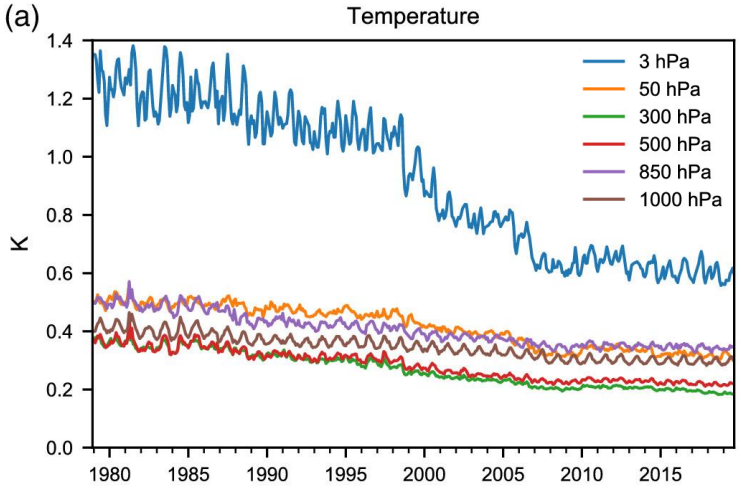
Background





Ensemble data assimilation spread versus pressure and time for Temperature in ERA5

Left: From Bell, B., et al. (2021) The ERA5 global reanalysis: Preliminary extension to 1950

Right: From Hersbach, H., et al. (2020) The ERA5 global reanalysis

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Background

- MW temperature sounder data are also used to monitor atmospheric temperature anomalies;
- MSU and AMSU-A measurements have been improved over the last decades;
- However, the calibration can be further improved, and measurement uncertainties can be estimated;
- SSM/T aboard of DMSP satellites operate parallel to MSU from 1991;
- SSM/T has more spectral channels providing more information of the higher atmosphere;
- SSM/T covering additional local equator crossing times;
- The value of using SSMIS data can be increased by using the highest peaking channels;
- Within a C3S framework this is being developed.

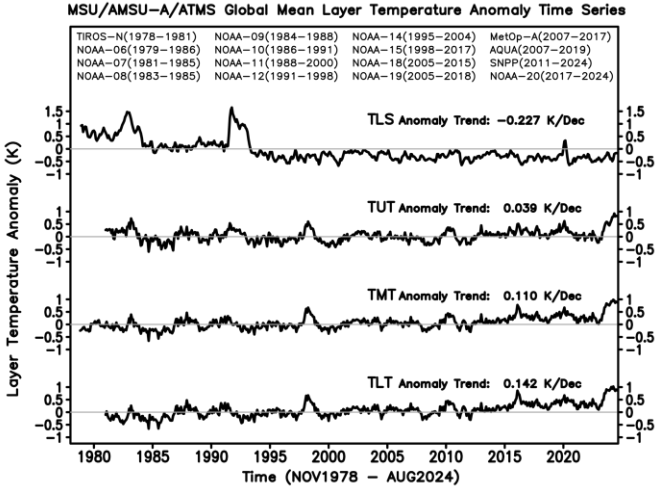

Figure taken from NOAA STAR

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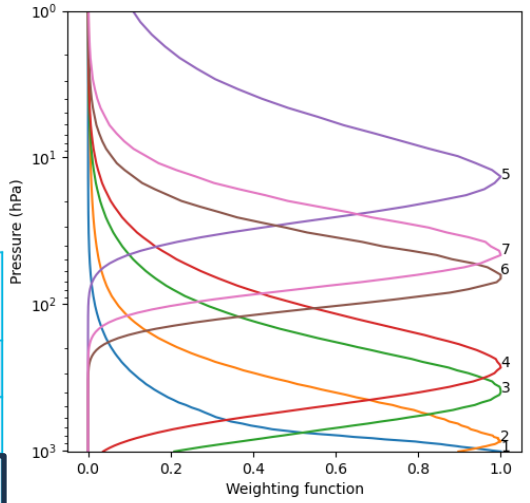
Preparing SSM/T for ERA-6

- Flown on DMSP satellites F11 to F15
- 7 channel cross track scanning radiometer

Channel No.	Central frequency [GHz]	Bandwidth [MHz]	NeΔT [K]	Peaking height [km]
1	50.50	400	0.6	0
2	53.20	400	0.4	2
3	54.35	400	0.4	6
4	54.90	400	0.4	10
5	58,40	115	0,5	30
6	58,825	400	0,4	16
7	59,40	250	0,4	22



Scan time [s]	32,0
Number of FOVs	7
IFOV nadir [km]	174
IFOV edge [km]	305x313
Swath width[km]	±1500

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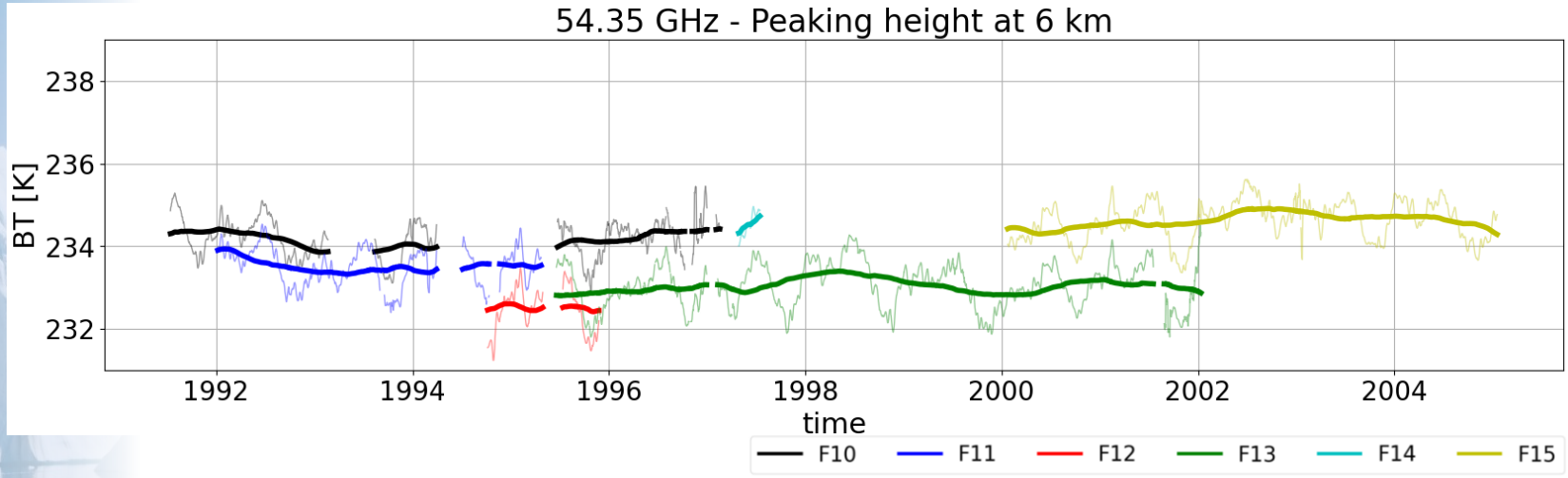
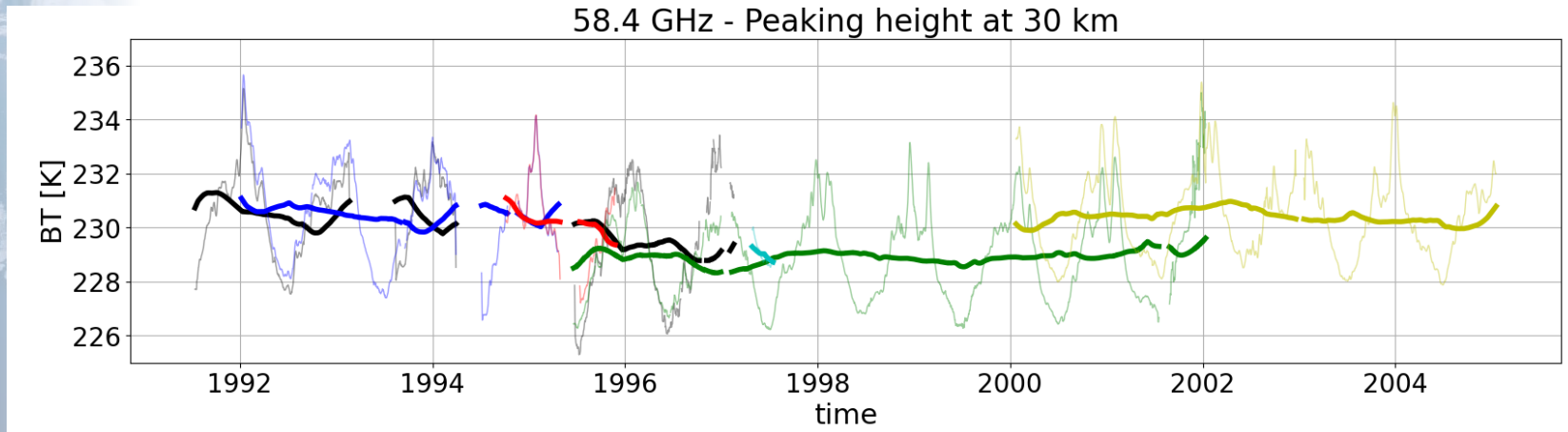
Time series of the SSM/T data record





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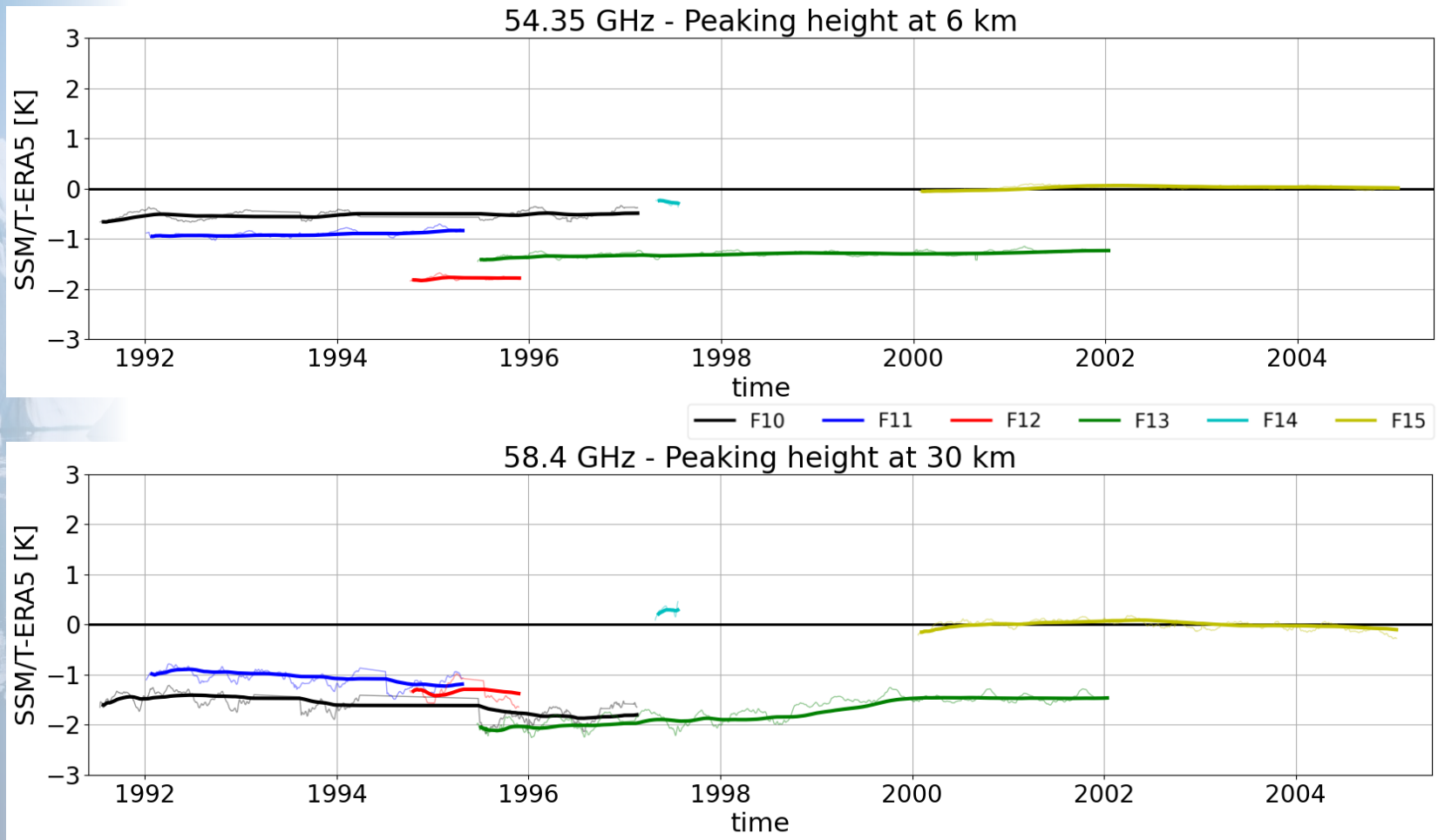
Obs – Sim | time series (SSM/T minus ERA5)



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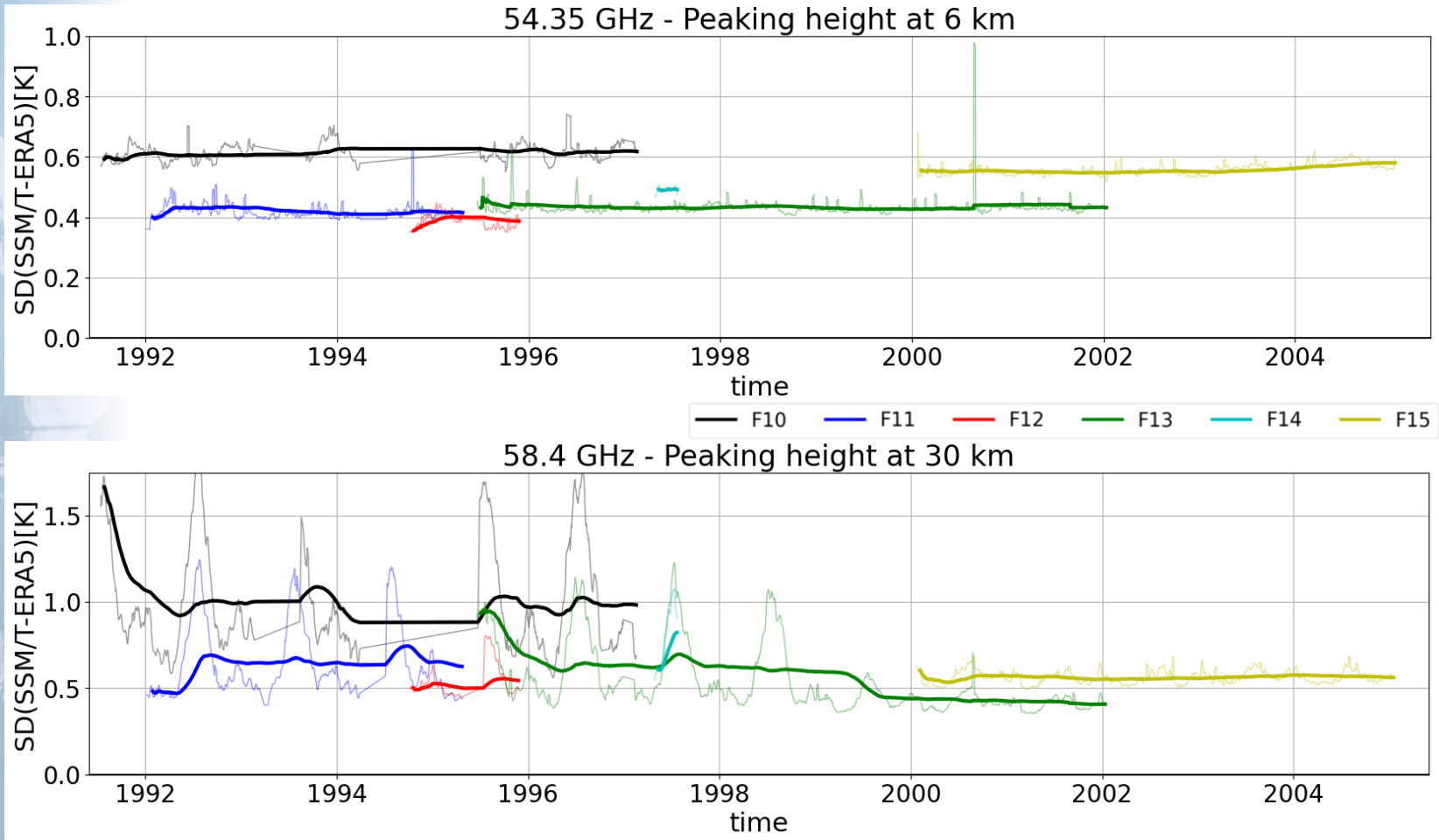
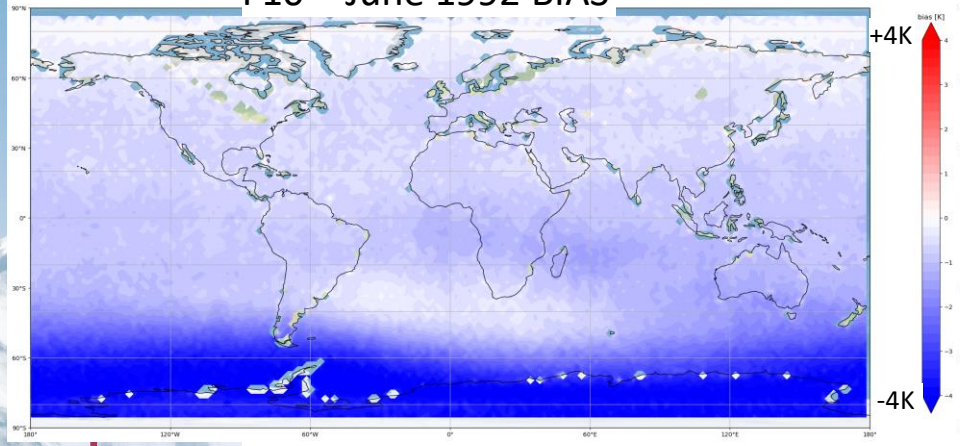
Obs – Sim | standard deviation

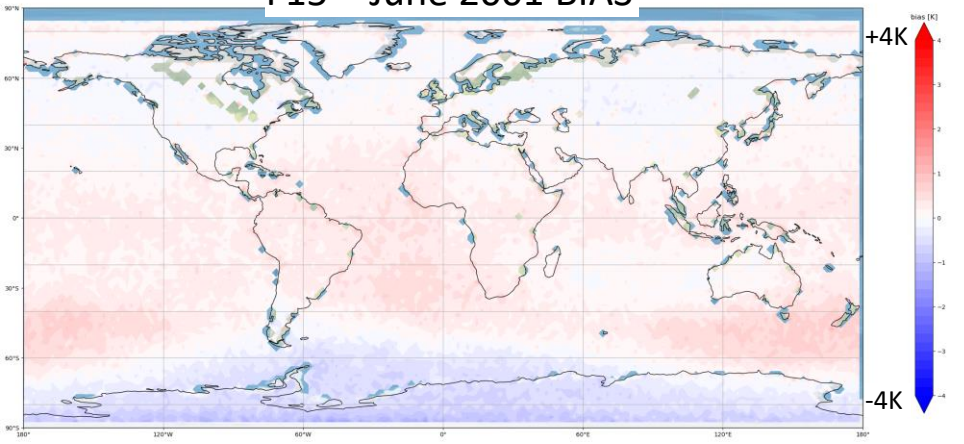


58.4 GHz Peaking height at 30km vs ERA-5

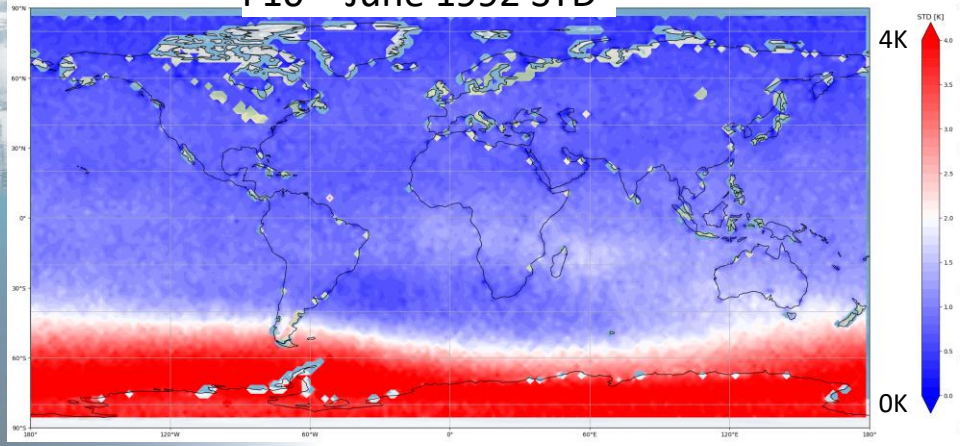
F10 – June 1992 BIAS



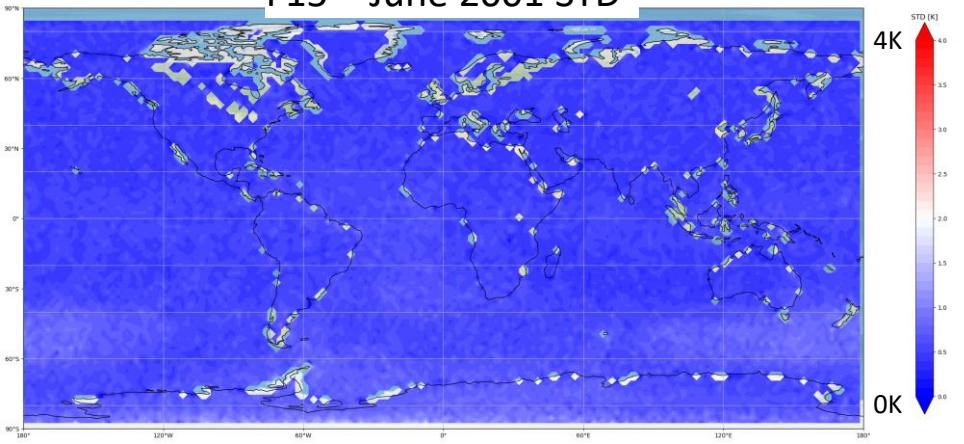
F15 – June 2001 BIAS



F10 – June 1992 STD



F15 – June 2001 STD



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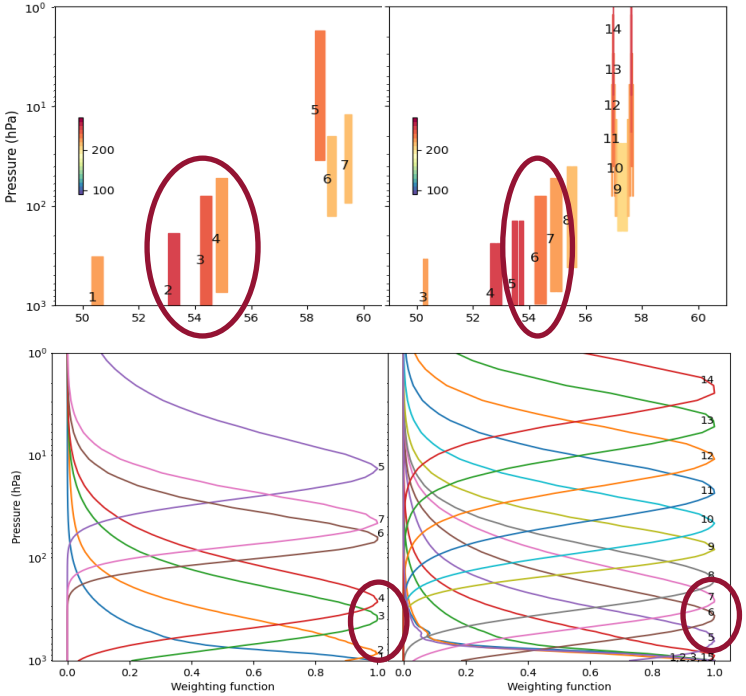
Validation of SSM/T

- AMSU-A for lower atmospheric channels:
  - NOAA 15 , 16, and 17;
  - Operational data from 2000 onwards;
  - 50.5GHz, **54.35GHz, and 54.9GHz**.
- Radio occultation (RO) for upper atmospheric channels:
  - RO from CHAMP satellite;
  - Data from 2000 onwards;
  - **54.35 GHz, 54.9GHz**, 58.825GHz, 59.4GHz, 58.4 GHz
  - Processed by EUMETSAT's Radio Occultation Meteorology Satellite Application Facility
  - Forward simulation using RTTOV



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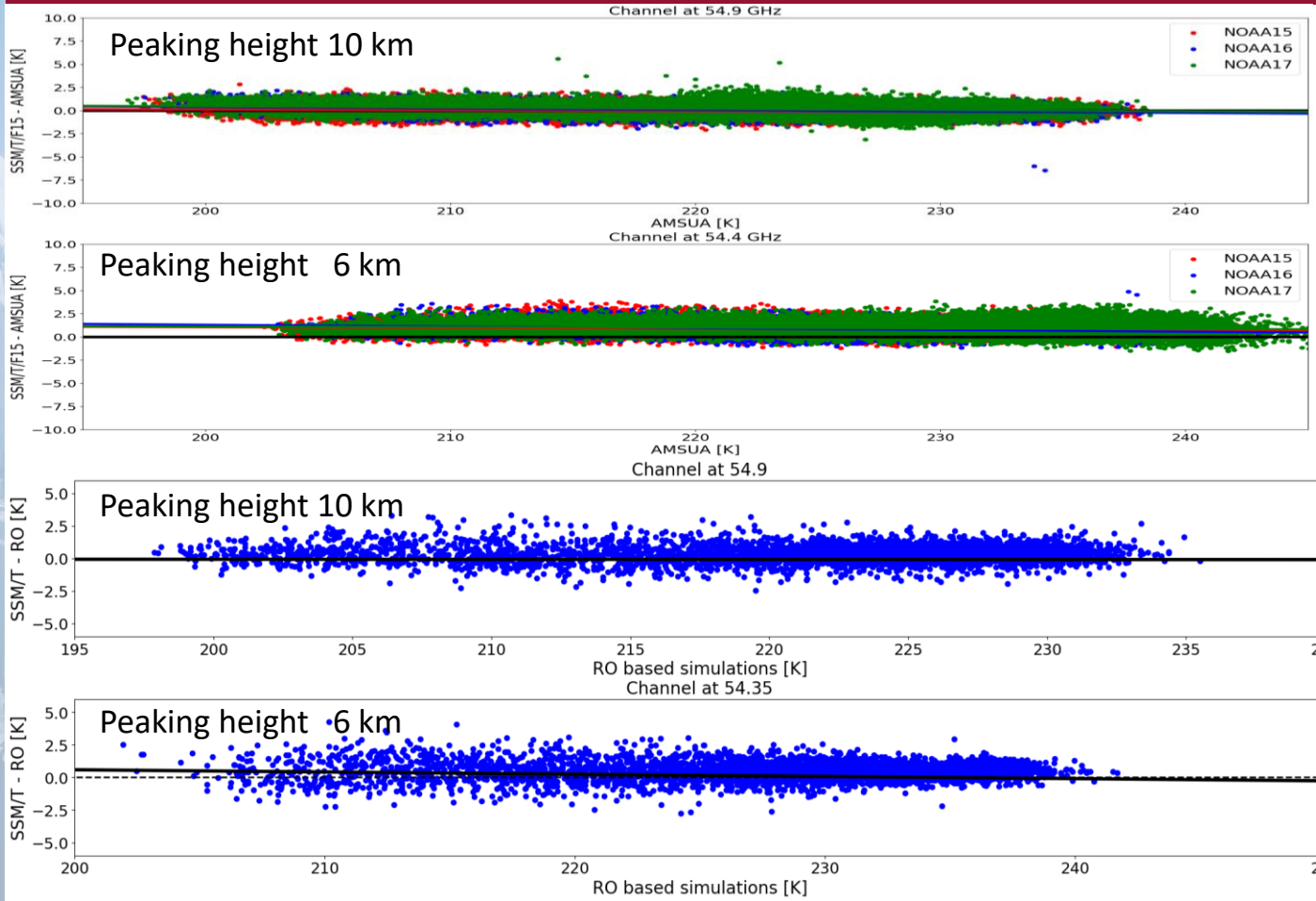

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Preparing SSMIS for ERA-6

Channel No.	Frequency [Pol]	Band	Spatial Sampling [km]	Channel No.	Frequency [Pol]	Band	Spatial Sampling [km]
1	50.3	LAS	37.5	13	19.35 [V]	ENV	25
2	52.8	LAS	37.5	14	22.235	ENV	25
3	53.596	LAS	37.5	15	37.0 [H]	ENV	25
4	54.4	LAS	37.5	16	37.0 [V]	ENV	25
5	55.5	LAS	37.5	17	91.655 ± 0.9 [V]	IMA	12.5
6	57.29	LAS	37.5	18	91.655 ± 0.9 [H]	IMA	12.5
7	59.4	LAS	37.5	19	63.28 ± 0.28	UAS	75
8	150±1.25	IMA	12.5	20	60.79 ± 0.36	UAS	75
9	183.31±6.6	IMA	12.5	21	60.79 ± 0.36 ± 0.002	UAS	75
10	183.31±3.0	IMA	12.5	22	60.79 ± 0.36 ± 0.0055	UAS	75
11	183.31±1.0	IMA	12.5	23	60.79 ± 0.36 ± 0.016	UAS	75
13	19.35 [H]	ENV	25	24	60.79 ± 0.36 ± 0.050	LAS	37.5

- conical scanning radiometer on board of DMSP satellites since F16
- 24 channels in 4 spectral bands

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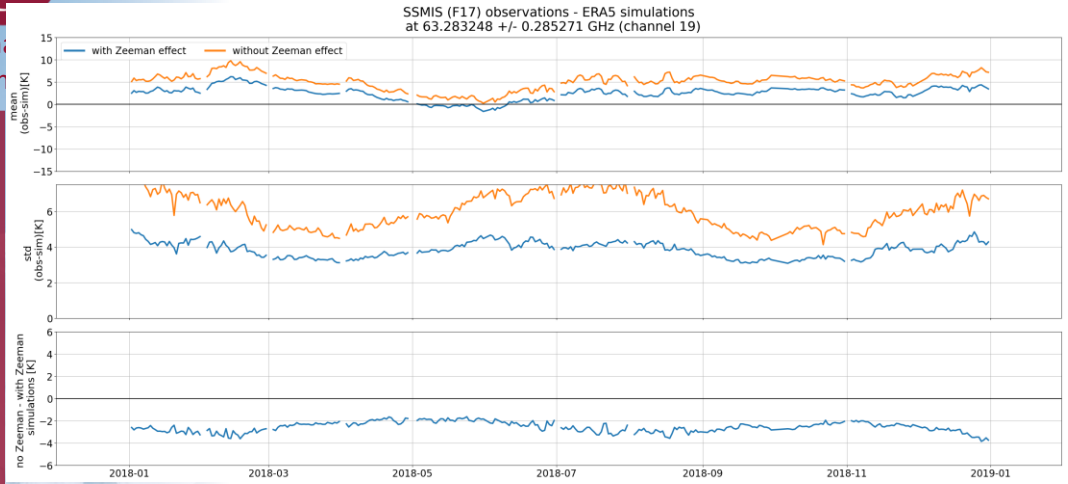
SSMIS in ERA-5

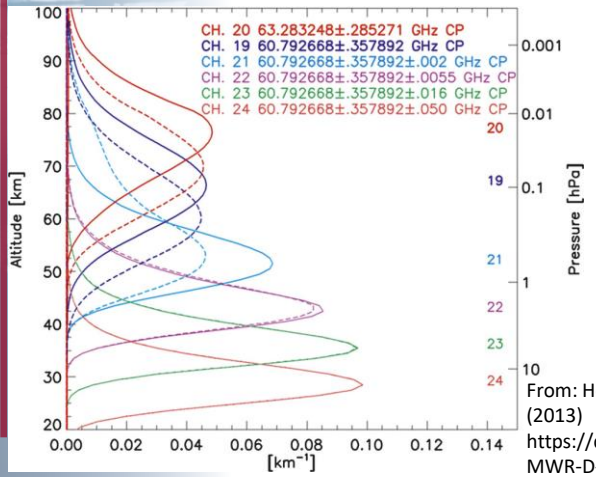
- In the (upper) mesosphere no observations are used in ERA-5;
- For the mesospheric channels (channels 19-21; ~50 – 80 km) - the Zeeman effect impacts the measurements;
- Information on earth magnetic field is necessary to assimilate these channels;
- We extend the F17 SSMIS files for 2018 by
  - dot product of geomagnetic field with the satellite propagation vector (B dot k)
  - Squared geomagnetic field strength ;
- We tested the impact on simulating the observations by considering the Zeemann effect.

Obs – Sim | time series (SSMIS minus ERA5)

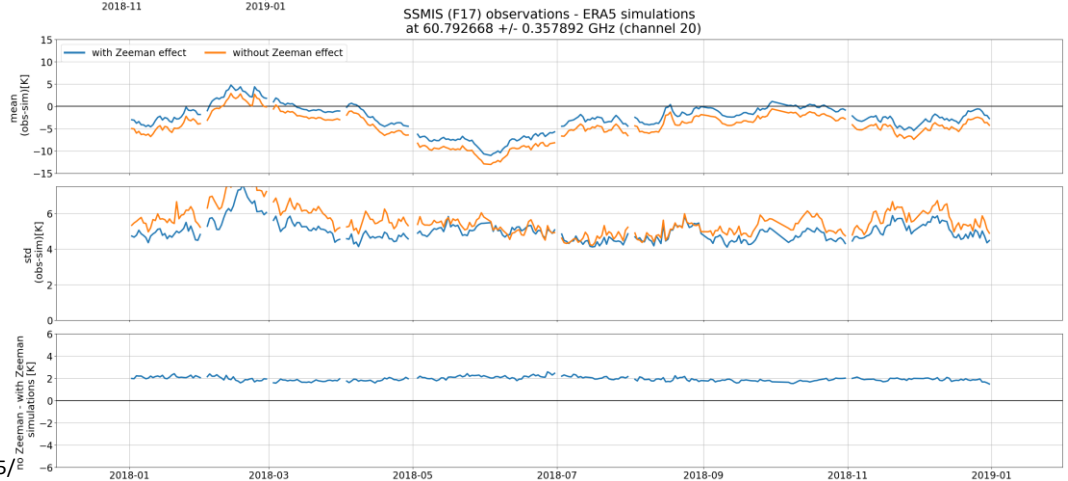


- We use RTTOV 13.2
- ERA5 describes the atmospheric state
- BUT:

! ERA5 top level at 0.01 hPa



From: Hoppel et al. (2013) https://doi.org/10.1175/MWR-D-13-00003.1



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Summary

- SSM/T data from DMSP satellites between 1991 and 2005 may add value to ERA6 and monitoring temperature anomalies;
- SSM/T data show very good temporal stability and low biases against radio occultation data and comparable quality to AMSU-A operational data;
- SSM/T data will likely improve the representation of the temperature diurnal cycle in the upper atmosphere in ERA6;
- SSM/T may alleviate stratospheric temperature biases in ERA5 in the 1990s;
- The SSM/T data record is available at DOI 10.15770/EUM_SEC_CLM_0085.

- We are working on an SSMIS data record including earth magnetic field information enabling the use of SSMIS UAS channels in future reanalysis;

- Uncertainty characterised MSU and AMSU-A data are planned to be reprocessed in the coming two years.

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