A Case Study of Two Intense Arctic Cyclones in Early June 2018

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What are Arctic Cyclones?

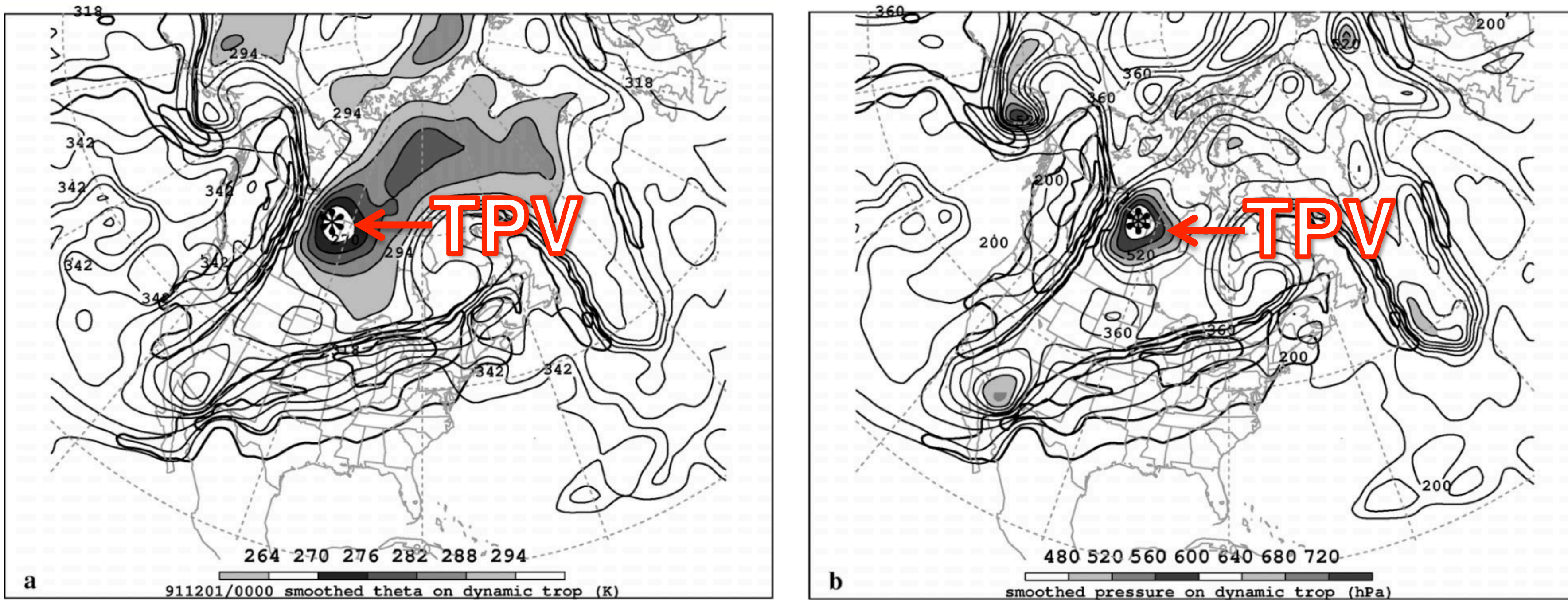
- Arctic cyclones are synoptic-scale cyclones that may originate within the Arctic or move into the Arctic from lower latitudes (e.g., Crawford and Serreze 2016)

- Arctic cyclones may be associated with strong surface winds and poleward advection of warm, moist air, contributing to reductions in Arctic sea-ice extent (e.g., Zhang et al. 2013)

- Heavy precipitation, strong surface winds, and large waves accompanying Arctic cyclones may pose hazards to ships navigating through open passageways in the Arctic Ocean

What are Tropopause Polar Vortices (TPVs)?

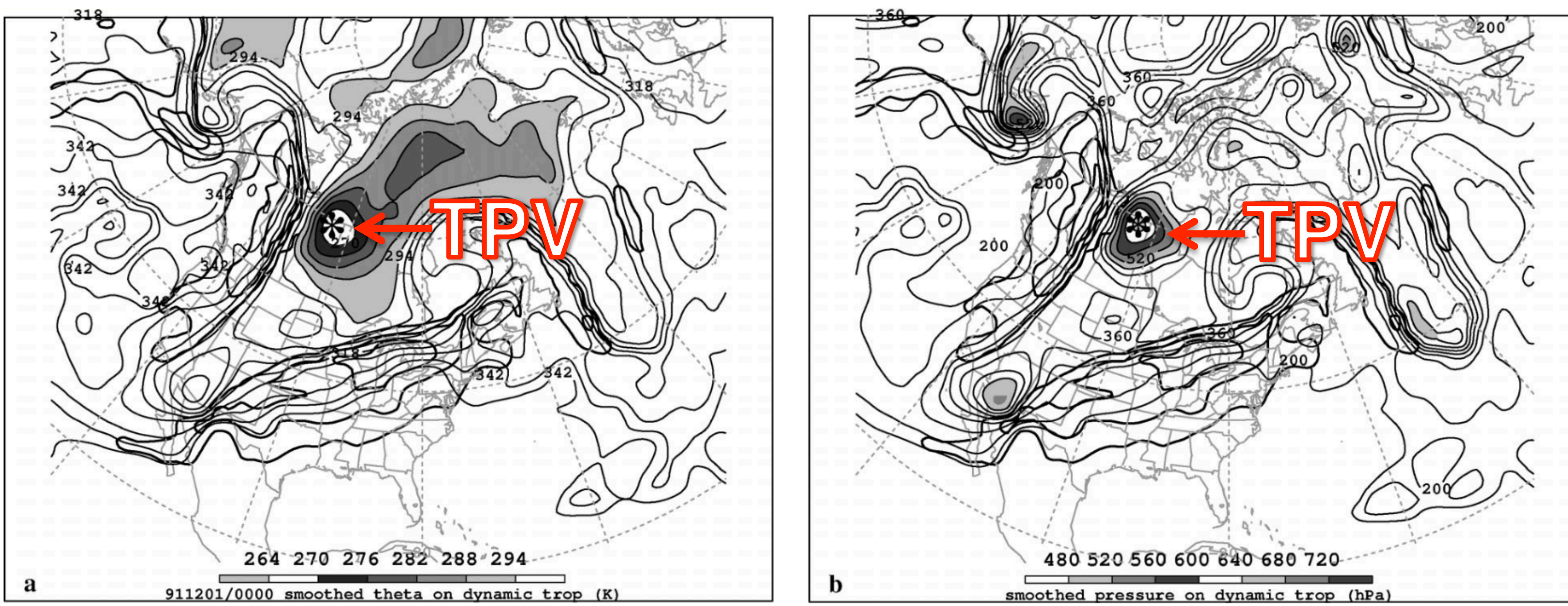
- TPVs are tropopause-based vortices of high-latitude origin and are material features (e.g., Pyle et al. 2004; Cavallo and Hakim 2009, 2010)



(left) Dynamic tropopause (DT) wind speed (every 15 m s^{-1} starting at 50 m s^{-1}, thick contours) and DT potential temperature (K, thin contours and shading) on 1.5-PVU surface valid at 0000 UTC 1 Dec 1991; **(right)** same as left except DT pressure (hPa, thin contours and shading).
Adapted from Fig. 11 in Pyle et al. (2004).

What are Tropopause Polar Vortices (TPVs)?

- TPVs may act as precursors to the development of Arctic cyclones (e.g., Tao et al. 2017)



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Case Overview

- Two sequential intense Arctic cyclones, AC1 and AC2, occurred in early June 2018
- AC1 forms northeast of the Caspian Sea within a frontal trough
- AC2 forms east of Greenland and may be linked to the remnants of Tropical Storm (TS) Alberto
- AC1 and AC2 strengthen over western Eurasia as they interact with TPVs
- AC1 and AC2 undergo a cyclonic rotation over the Arctic Ocean, during which AC2 absorbs AC1

Data and Methods

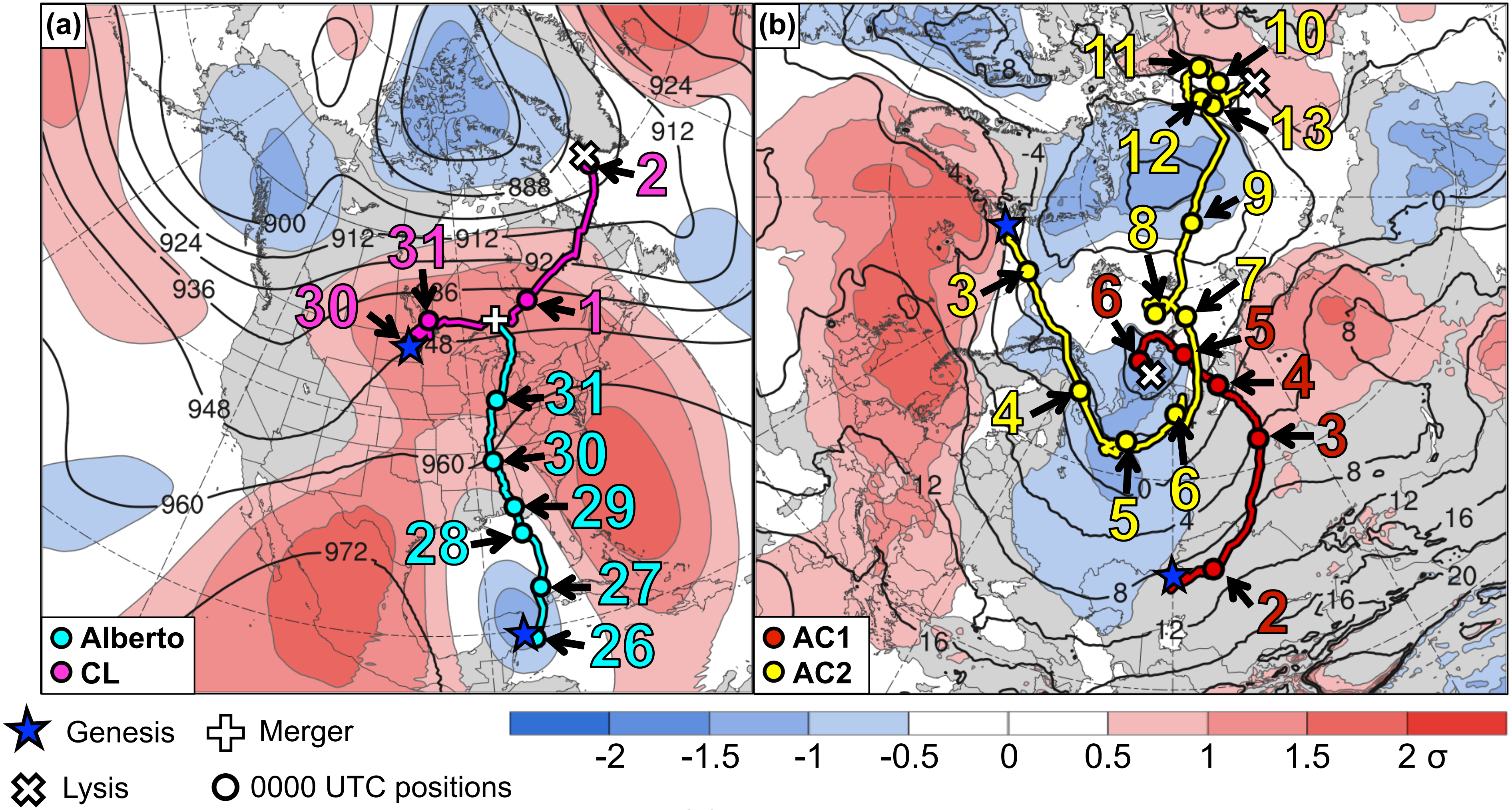
- Obtained gridded analyses from ERA-5 (Hersbach and Dee 2016) at 0.25° resolution

- Tracked cyclones manually by following locations of minimum sea level pressure (SLP)

- Identified and tracked TPVs objectively by utilizing a TPV tracking algorithm (Szapiro and Cavallo 2018)

- Computed backward trajectories by using NOAA HYSPLIT trajectory model

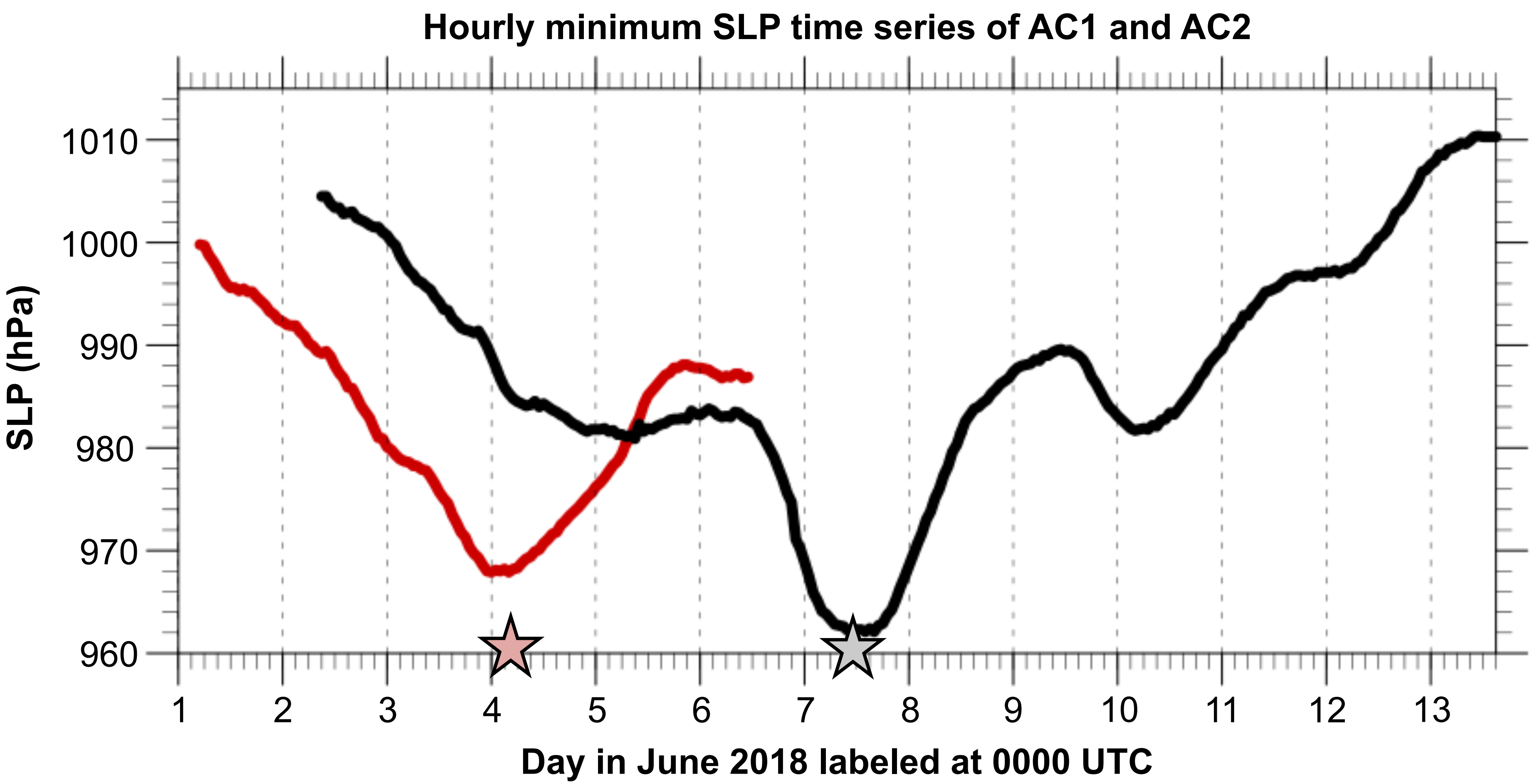
Track and Intensity of Cyclones



Cyclone	Genesis	Lysis	Lifetime
AC1	1 June	6 June	~5 d
AC2	2 June	13 June	~11 d

(a) 26 May–1 June 2018 time-mean 300-hPa geopotential height (dam, black) and standardized geopotential height anomalies (σ, shaded); (b) 1–7 June 2018 time-mean 850-hPa temperature (°C, black) and standardized temperature anomalies (σ, shaded).

Track and Intensity of Cyclones



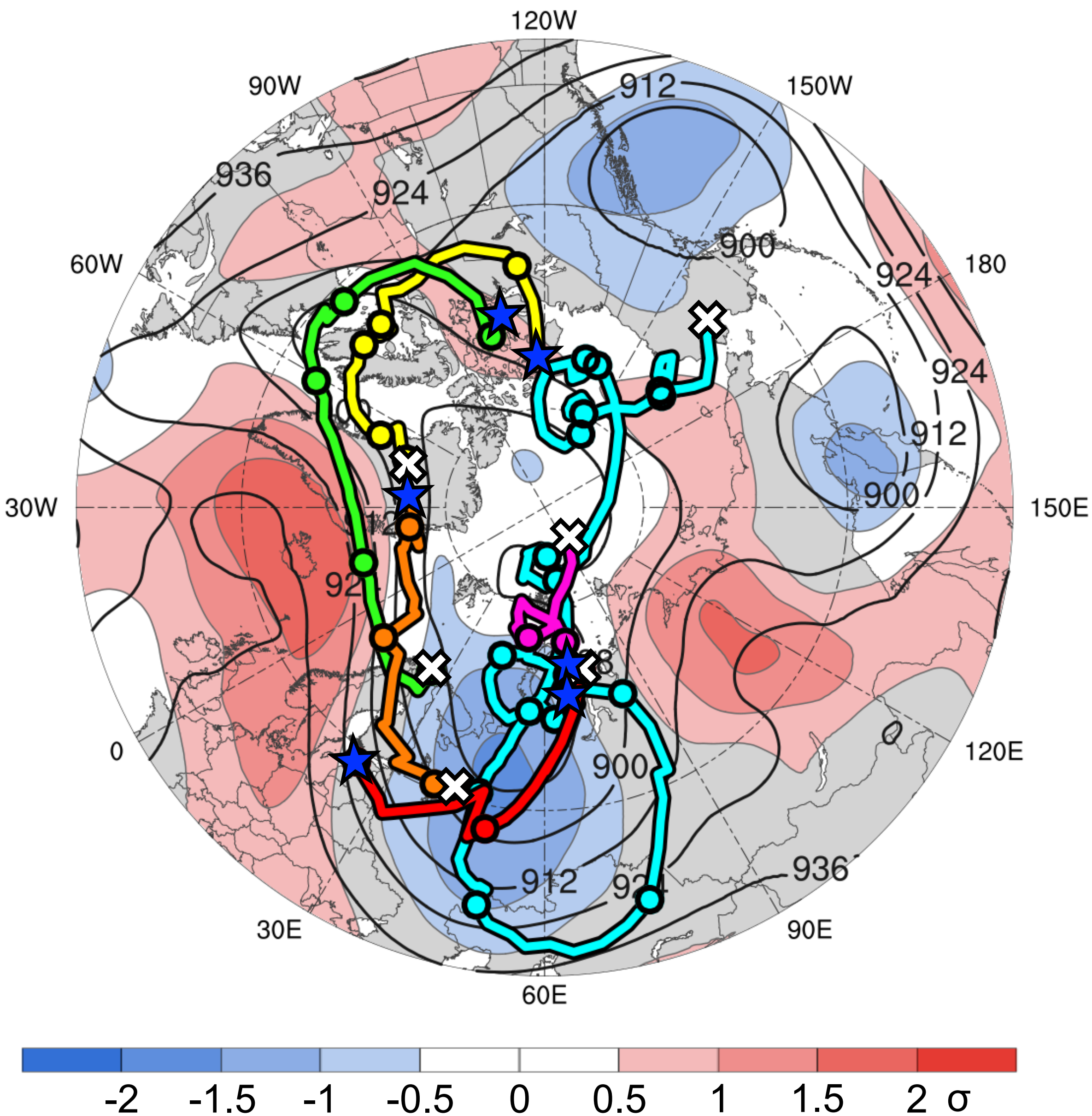
AC1

AC2

Peak intensity of AC1 at 0400 UTC 4 June 2018 (967.9 hPa)

Peak intensity of AC2 at 1100 UTC 7 June 2018 (962.0 hPa)

Tracks of TPVs



TPV	Genesis	Lysis	Lifetime
TPV 1a	29 May	3 June	~5.4 d
TPV 1b	2 June	5 June	2.5 d
TPV 1c	5 June	7 June	~2.4 d
TPV 1d	6 June	8 June	2 d
TPV 2	30 May	4 June	~4.4 d
TPV 3	30 May	15 June	~17 d

TPV 1a **TPV 1d**
TPV 1b **TPV 2**
TPV 1c **TPV 3**

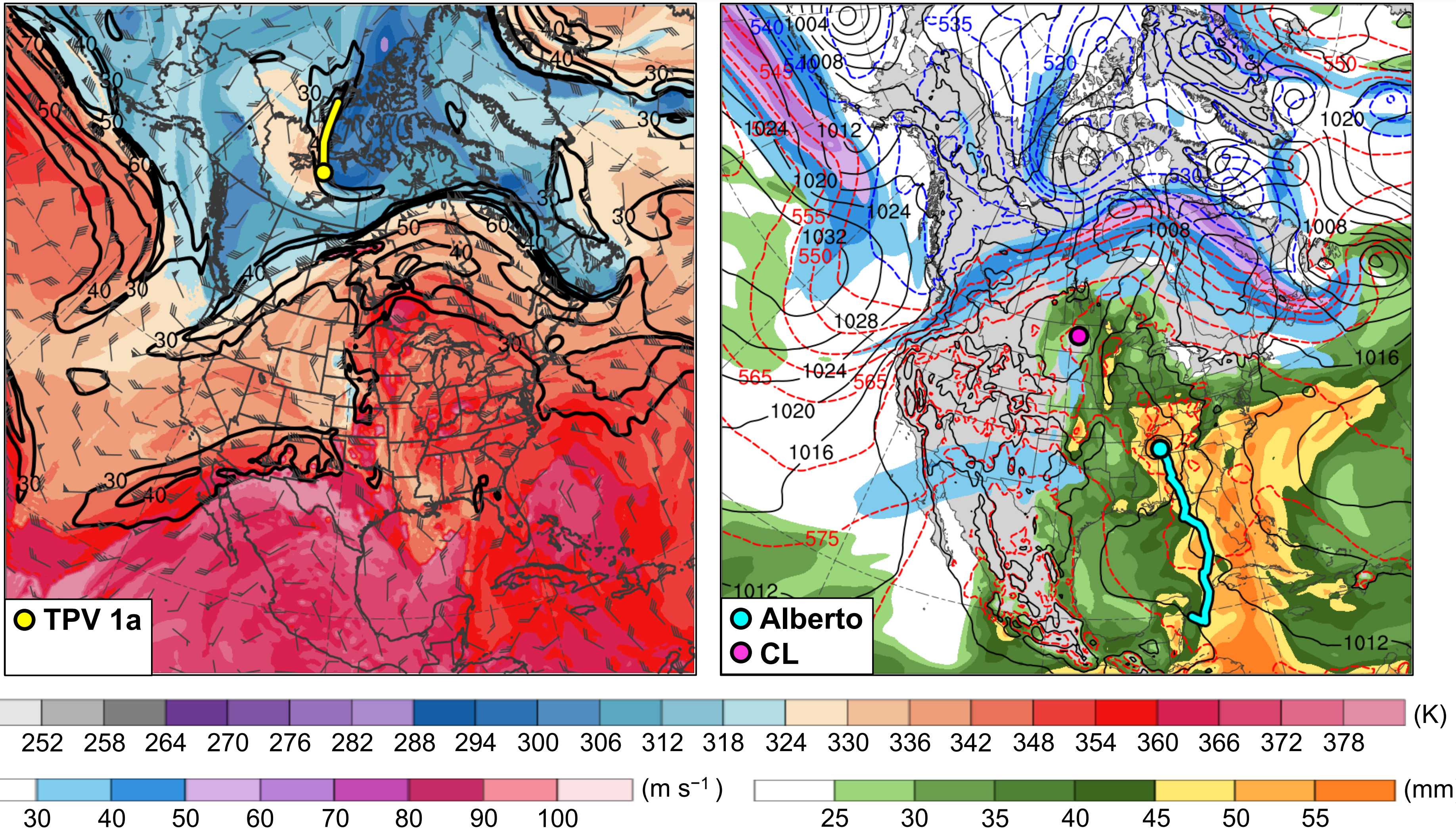
Genesis **Lysis**

0000 UTC positions

1–7 June 2018 time-mean 300-hPa geopotential height (dam, black) and standardized geopotential height anomalies (σ, shaded)

Synoptic Evolution

0000 UTC 30 May 2018



Potential temperature (K, shaded), wind speed (black, every 10 m s^{-1} starting at 30 m s^{-1}), and wind (m s^{-1}, flags and barbs) on 2-PVU surface

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Synoptic Evolution

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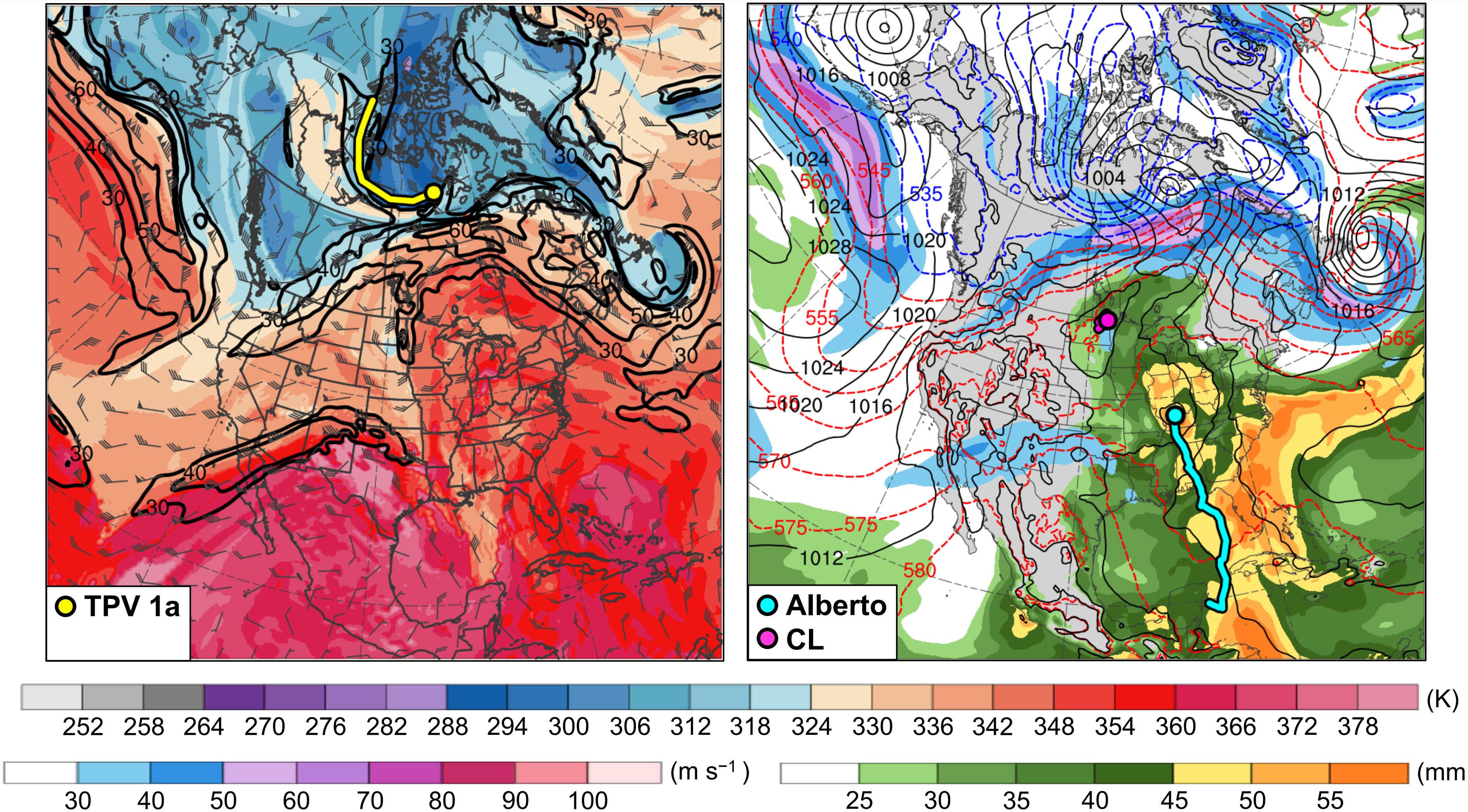

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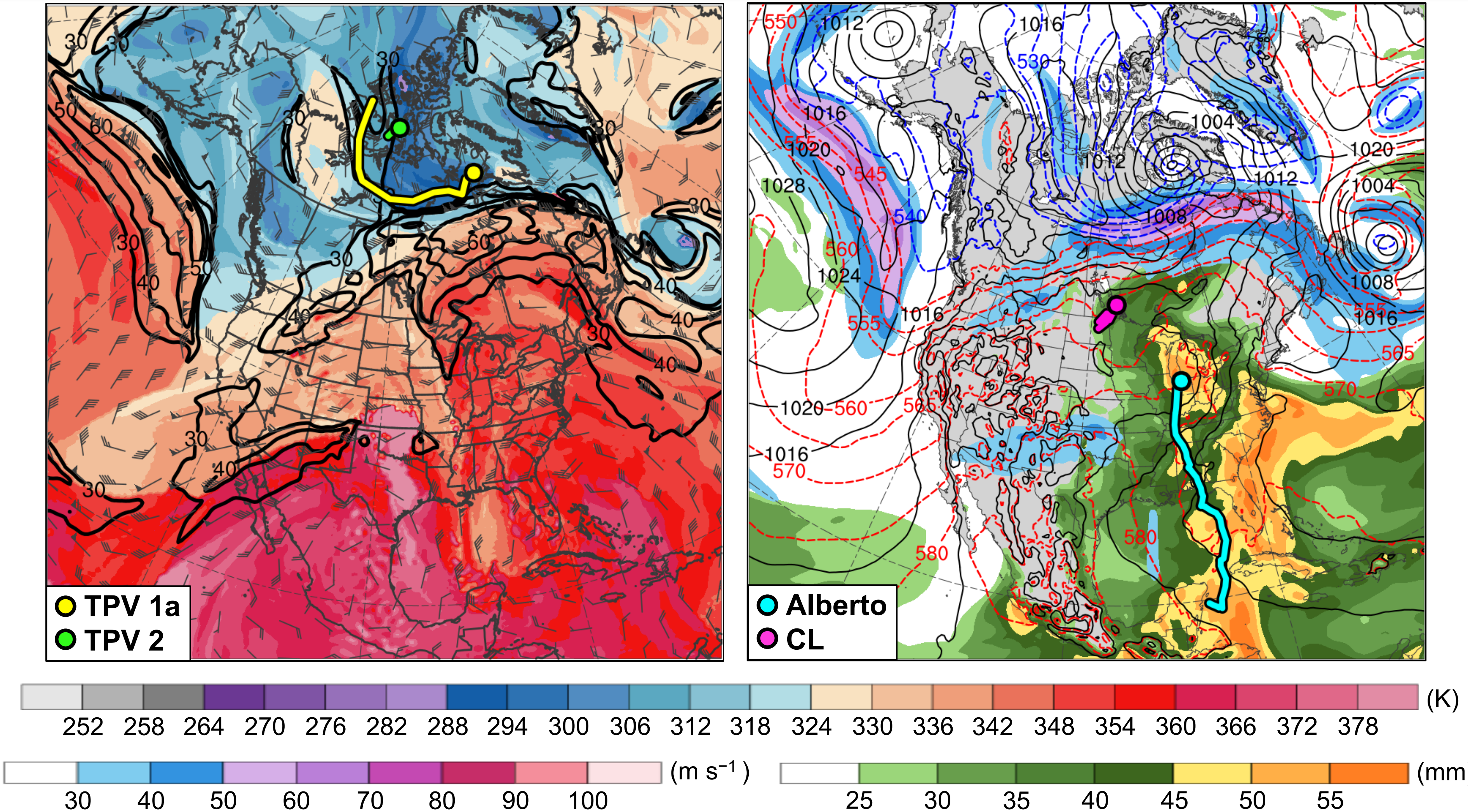

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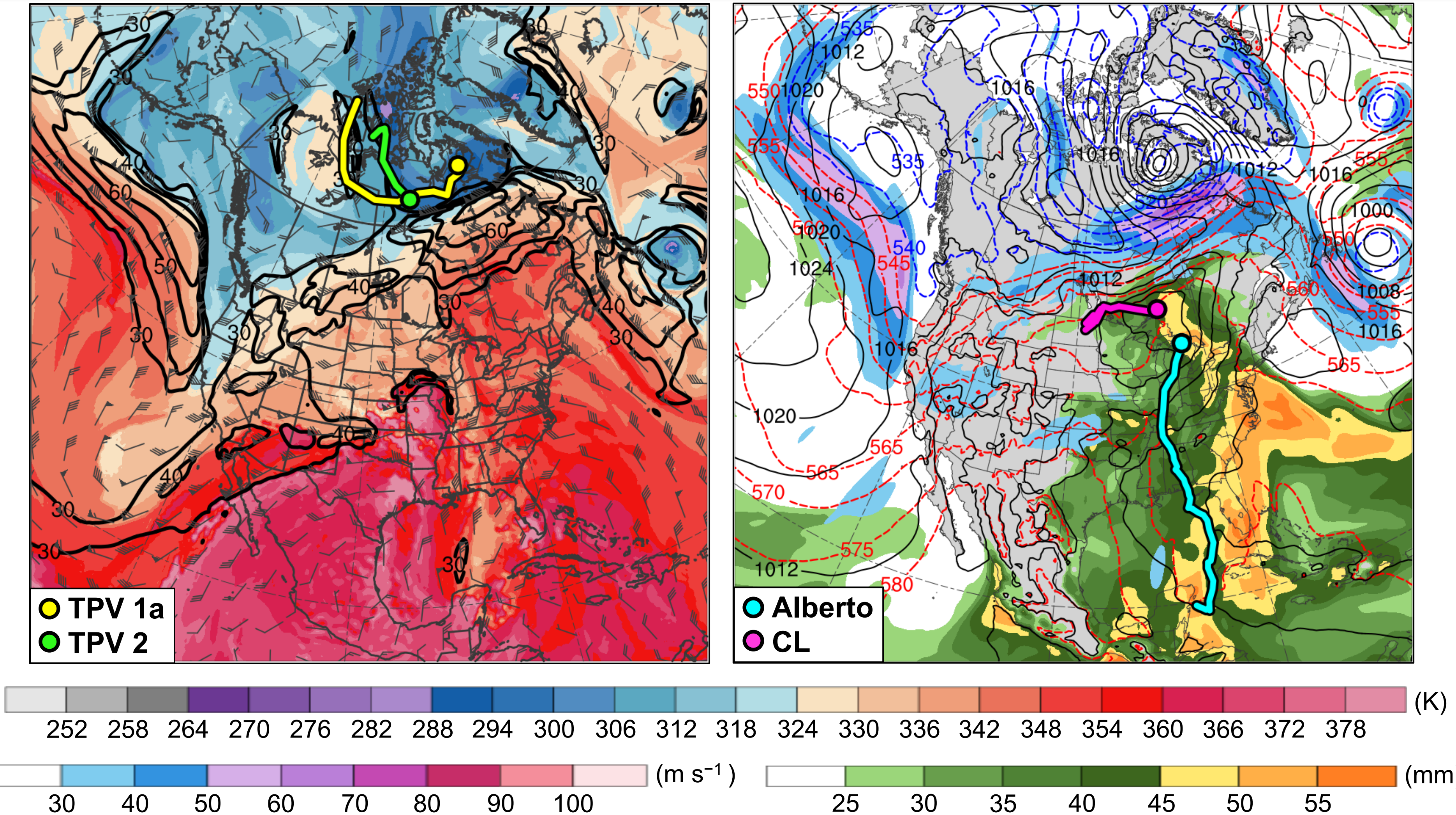

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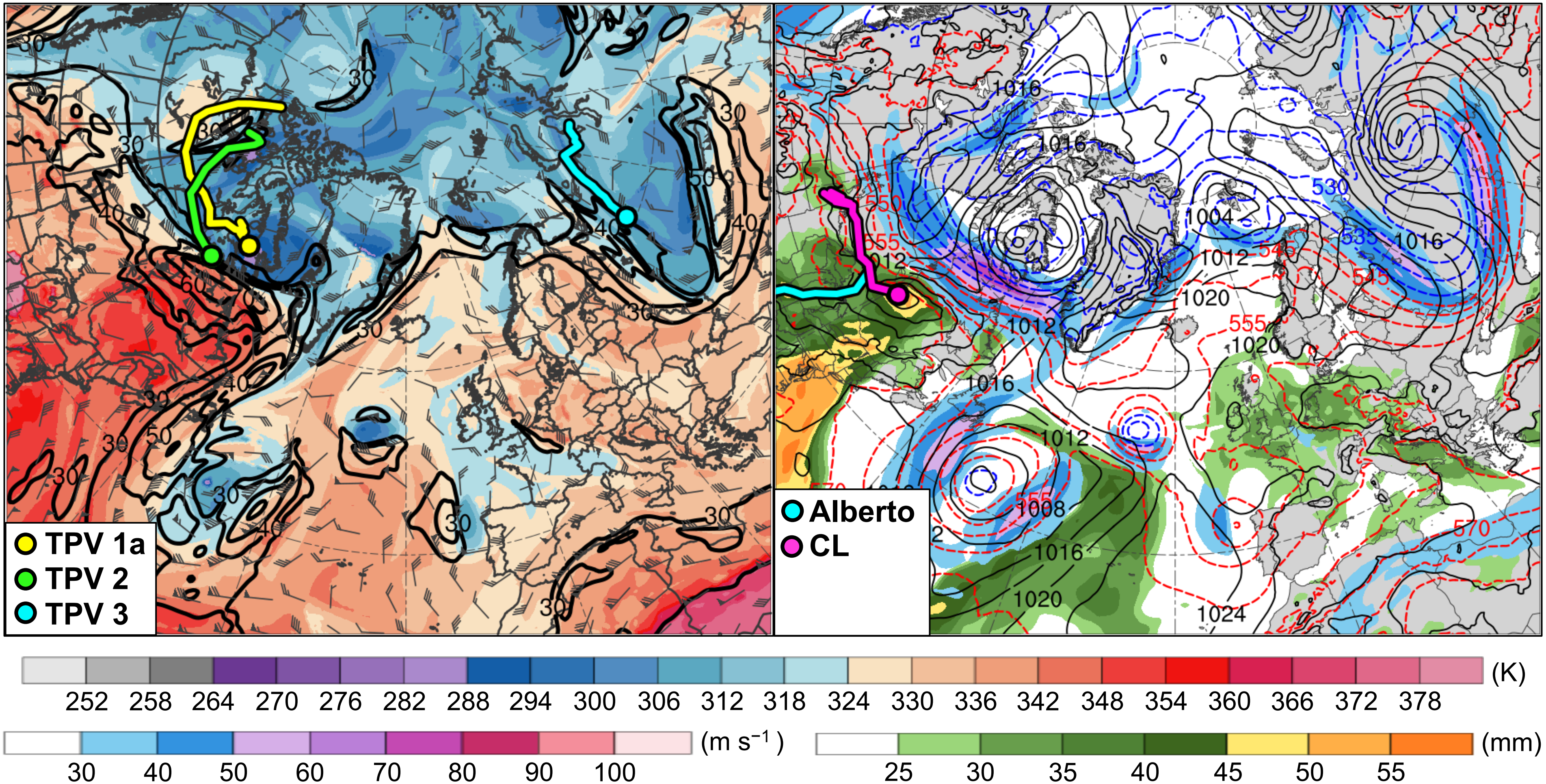
Synoptic Evolution

0000 UTC 1 June 2018



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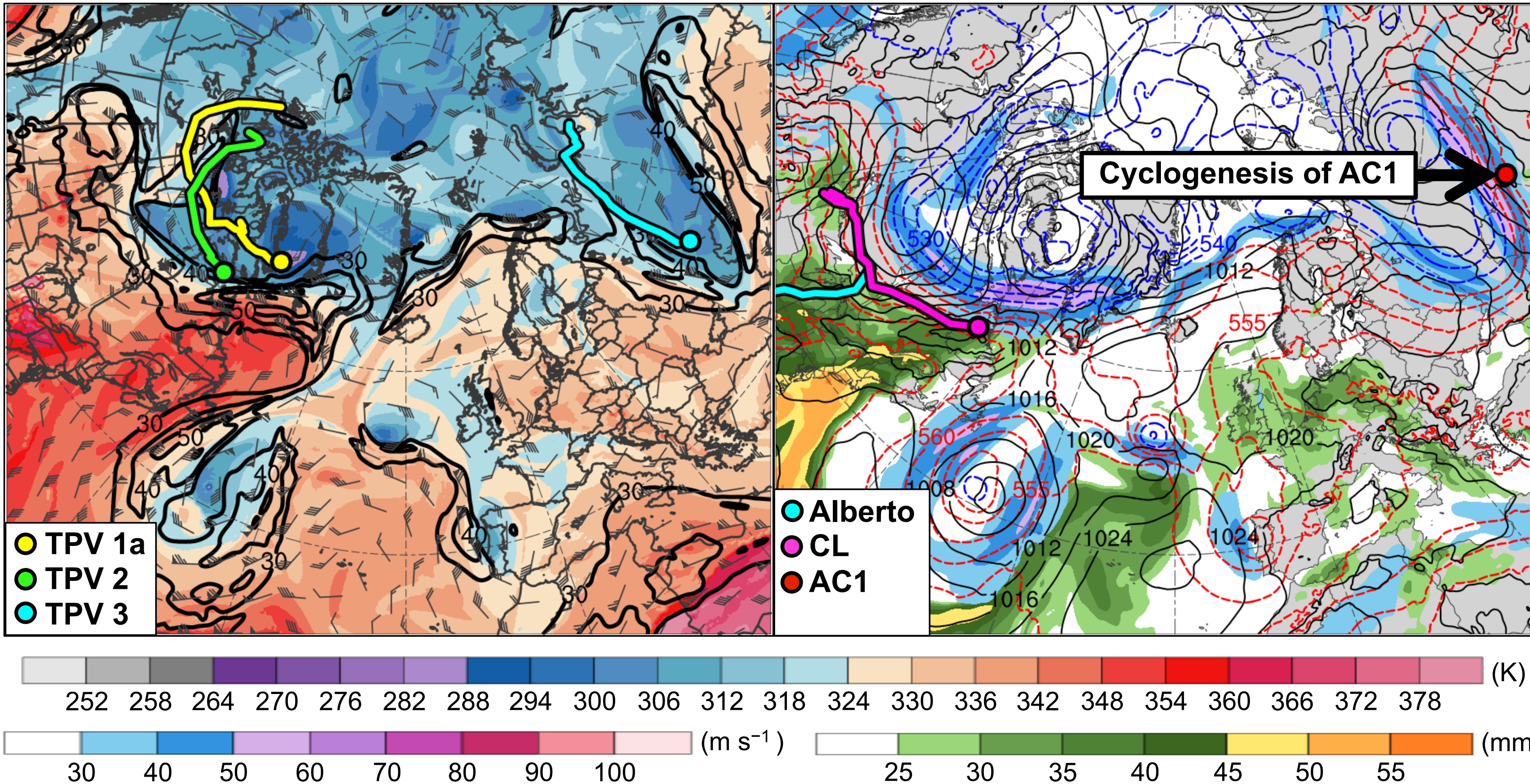

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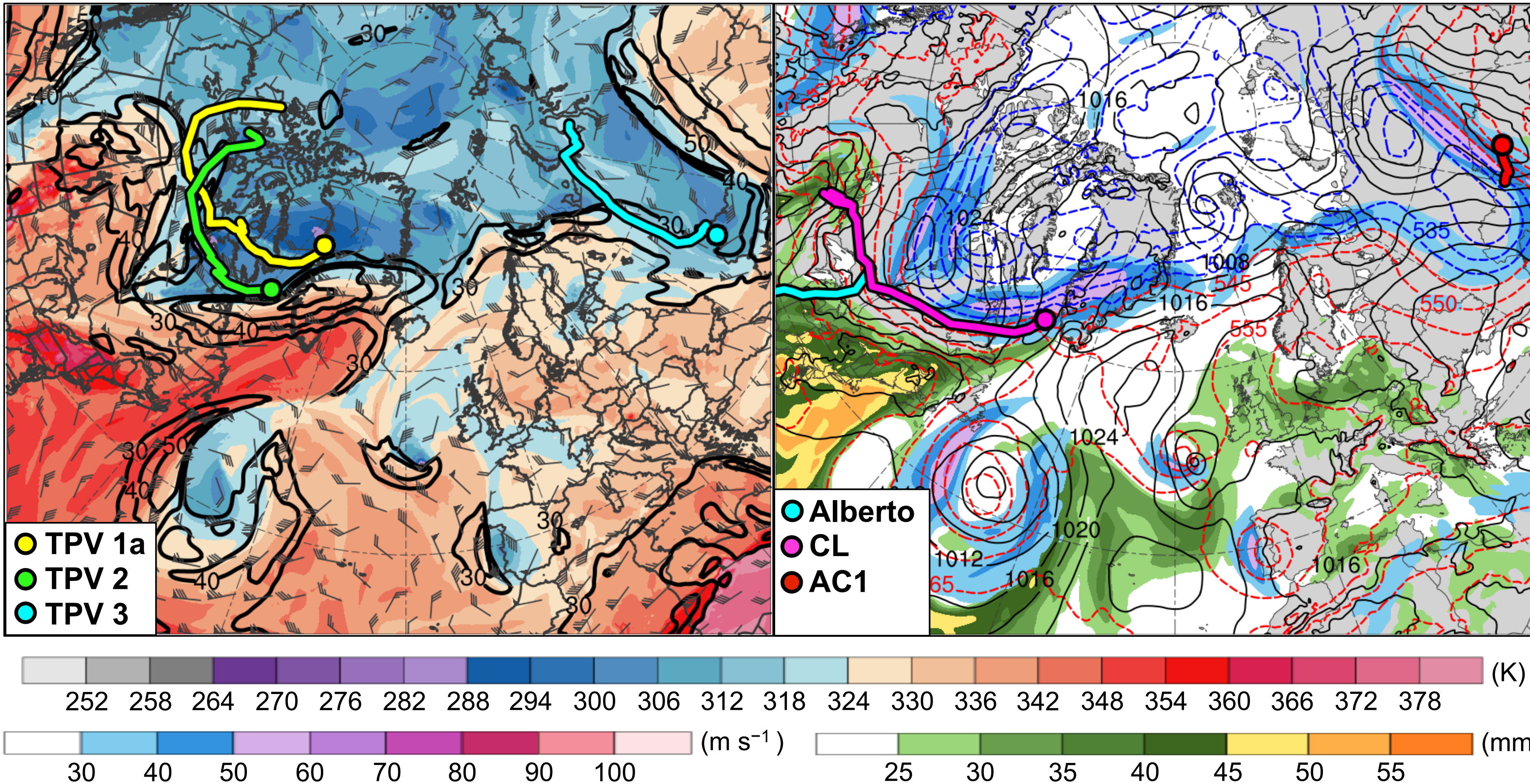
Synoptic Evolution

0000 UTC 2 June 2018



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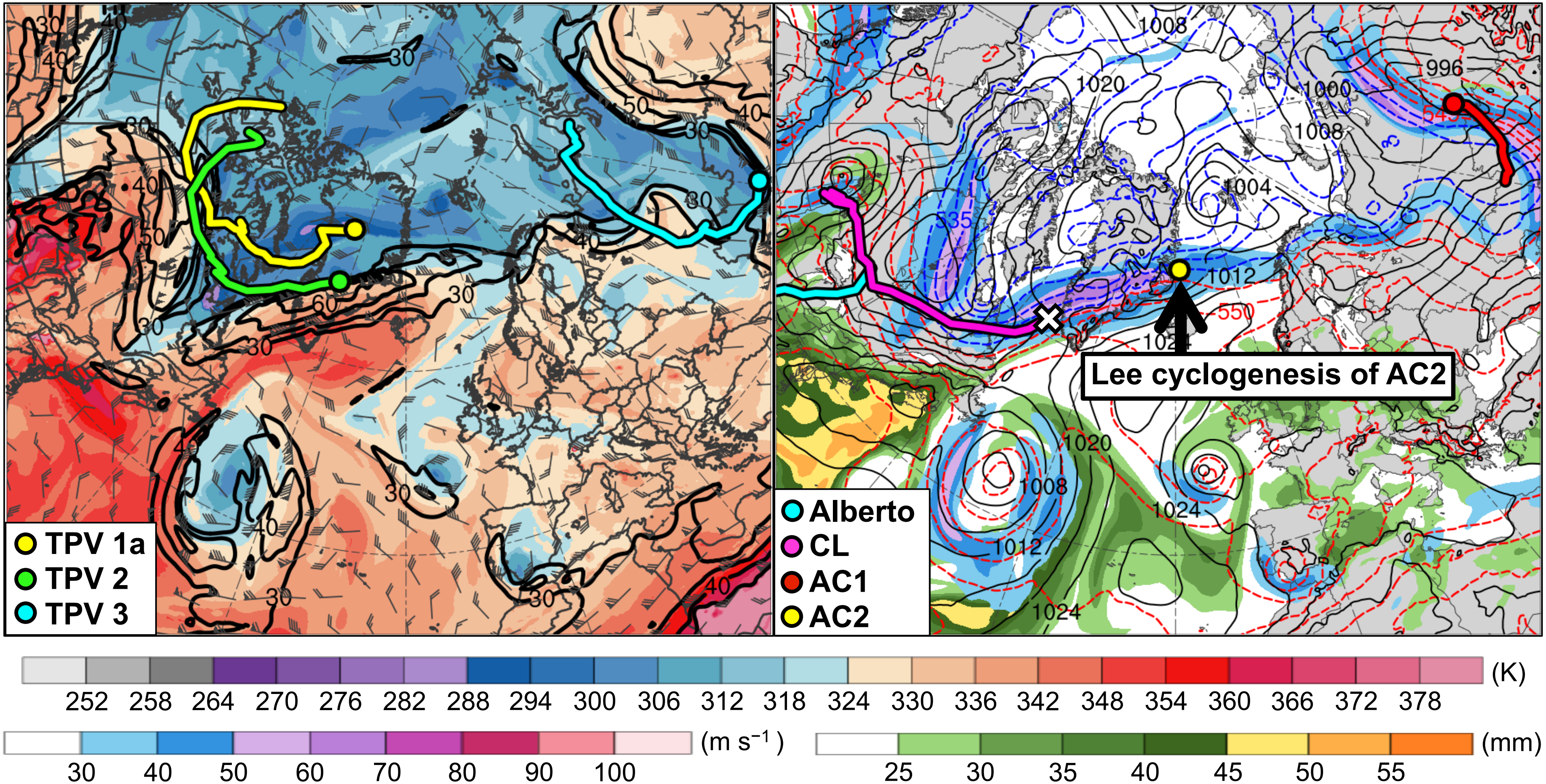

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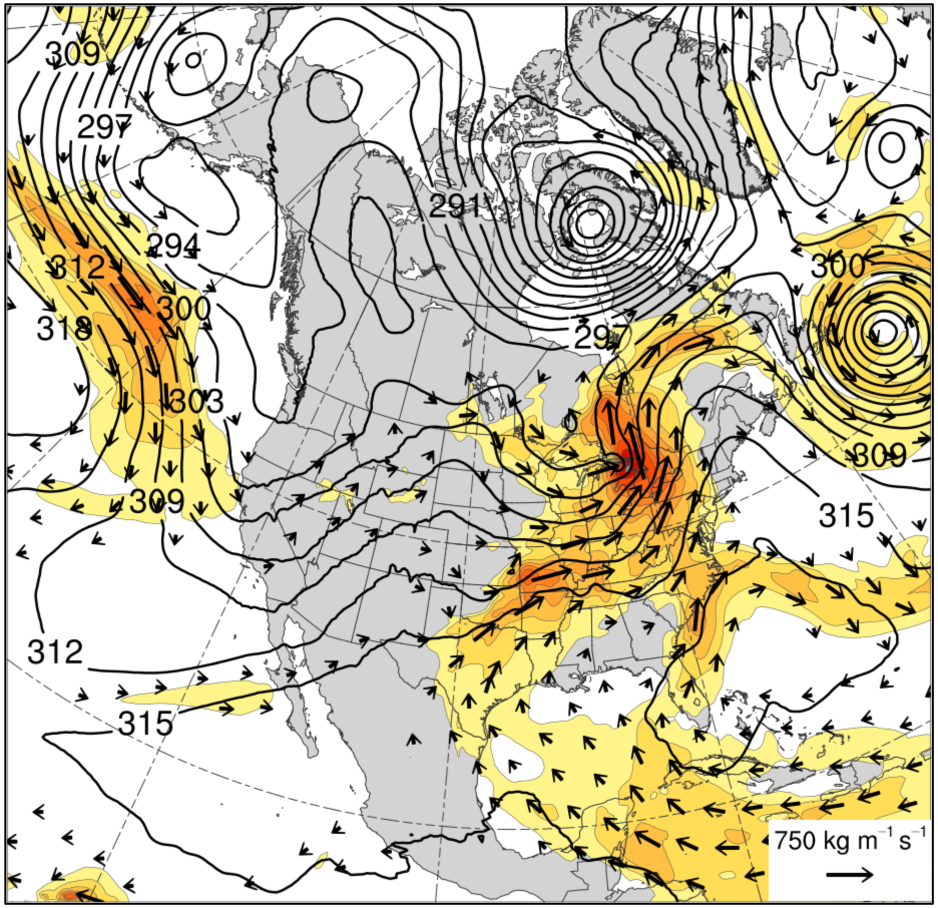
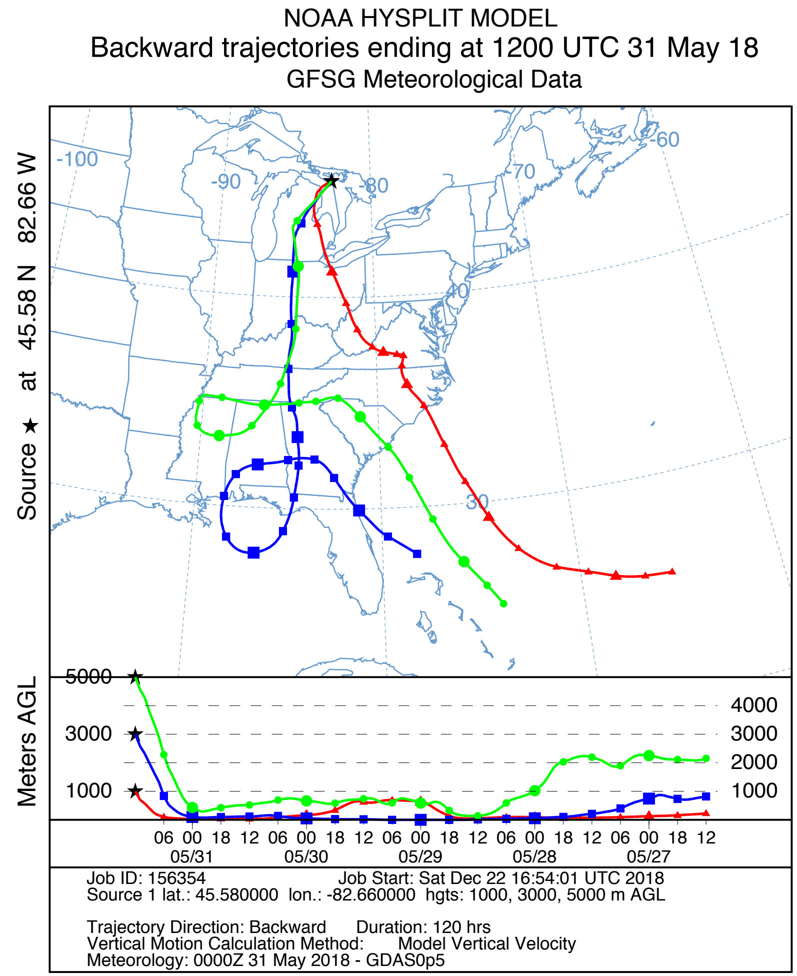
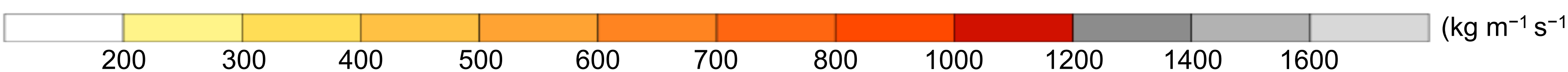
Moisture from TS Alberto

1200 UTC 31 May 2018



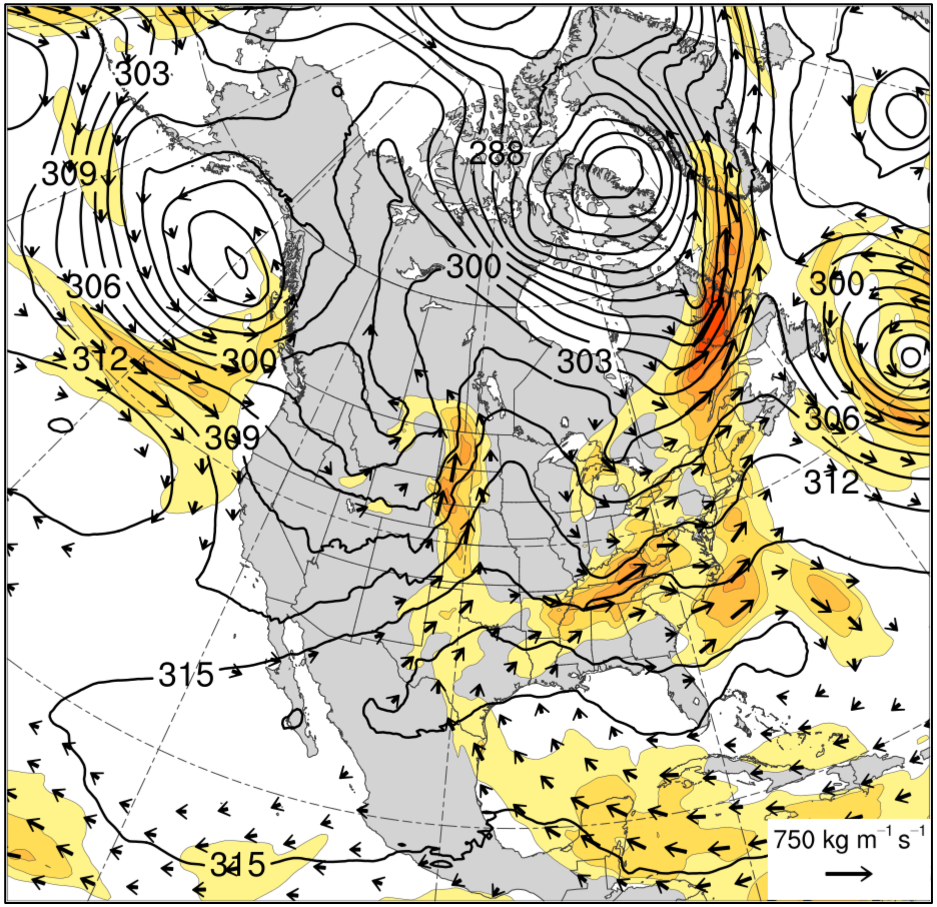


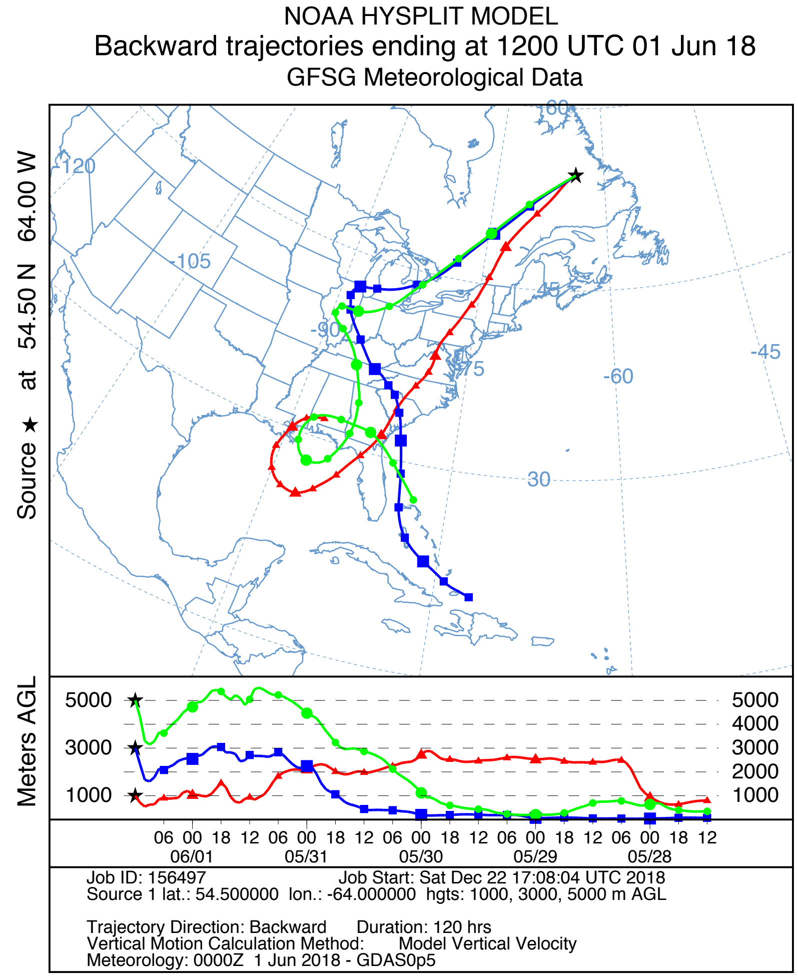


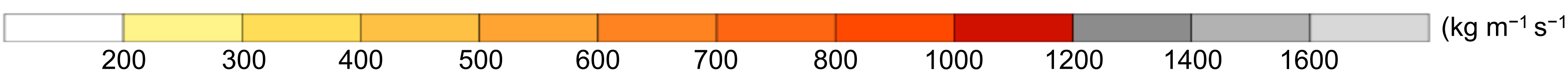
IVT (kg m^{-1} s^{-1}, shaded and vectors) and 700-hPa geopotential height (dam, black)	NOAA HYSPLIT 5-d backward trajectories ending at 1200 UTC 31 May 2018

Moisture from TS Alberto

1200 UTC 1 June 2018





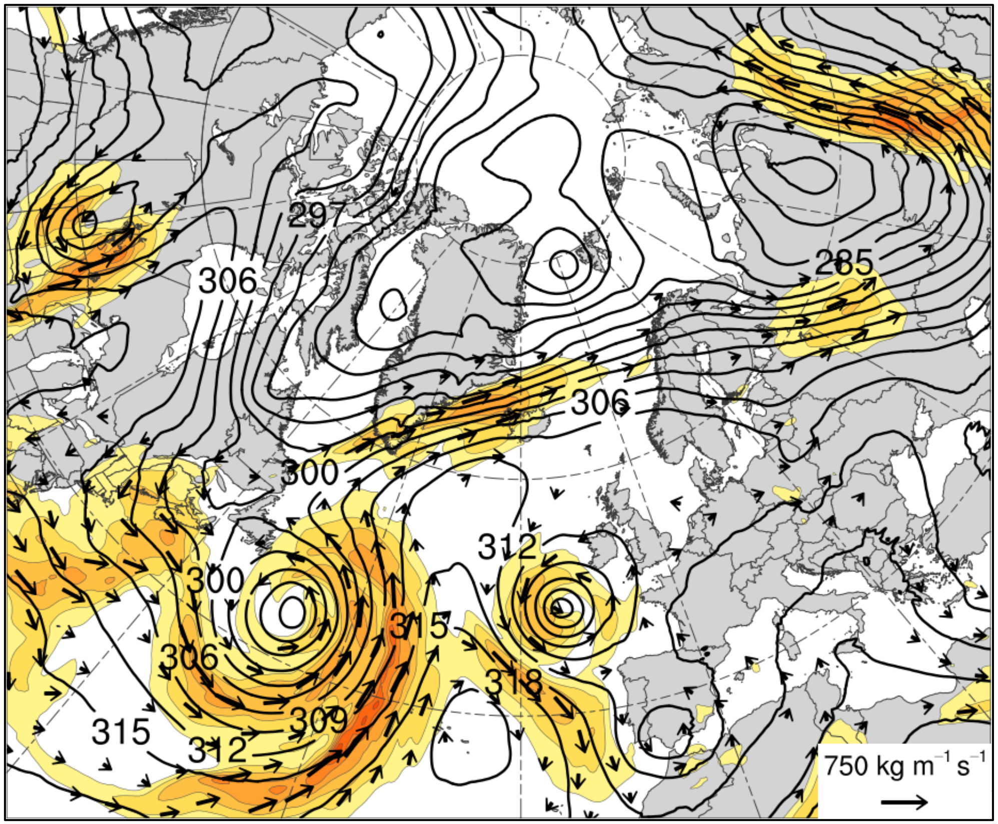


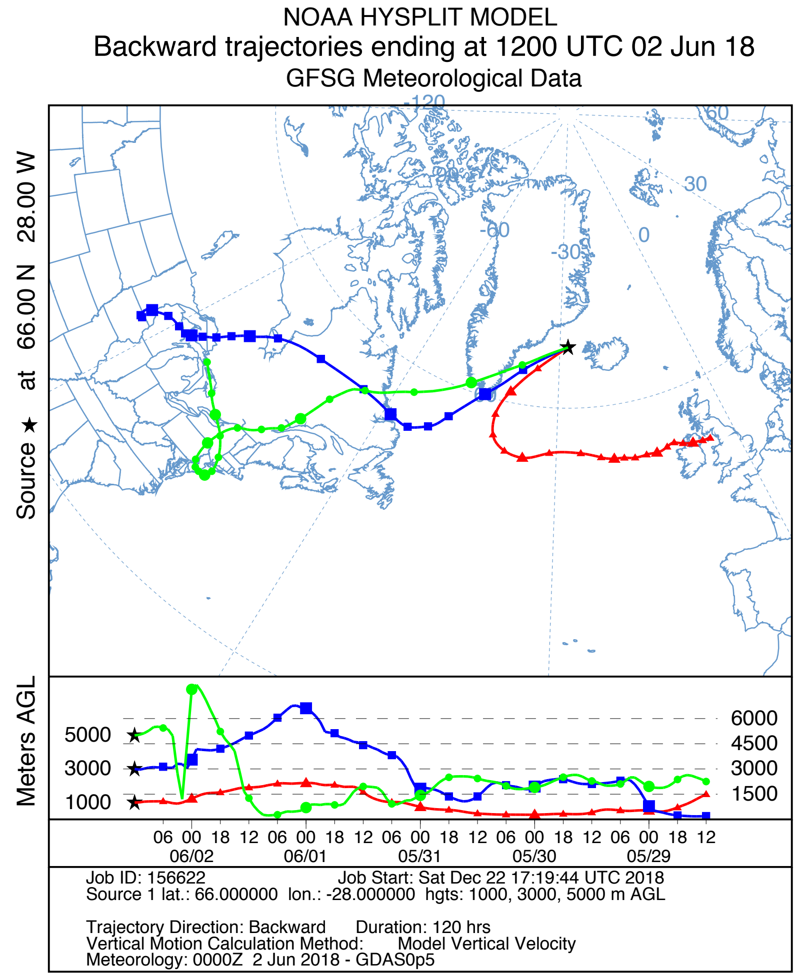
IVT (kg m^{-1} s^{-1}, shaded and vectors) and 700-hPa geopotential height (dam, black)

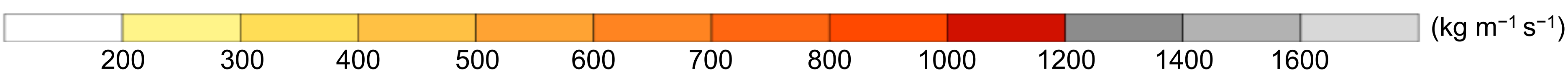
NOAA HYSPLIT 5-d backward trajectories ending at 1200 UTC 1 June 2018

Moisture from TS Alberto

1200 UTC 2 June 2018







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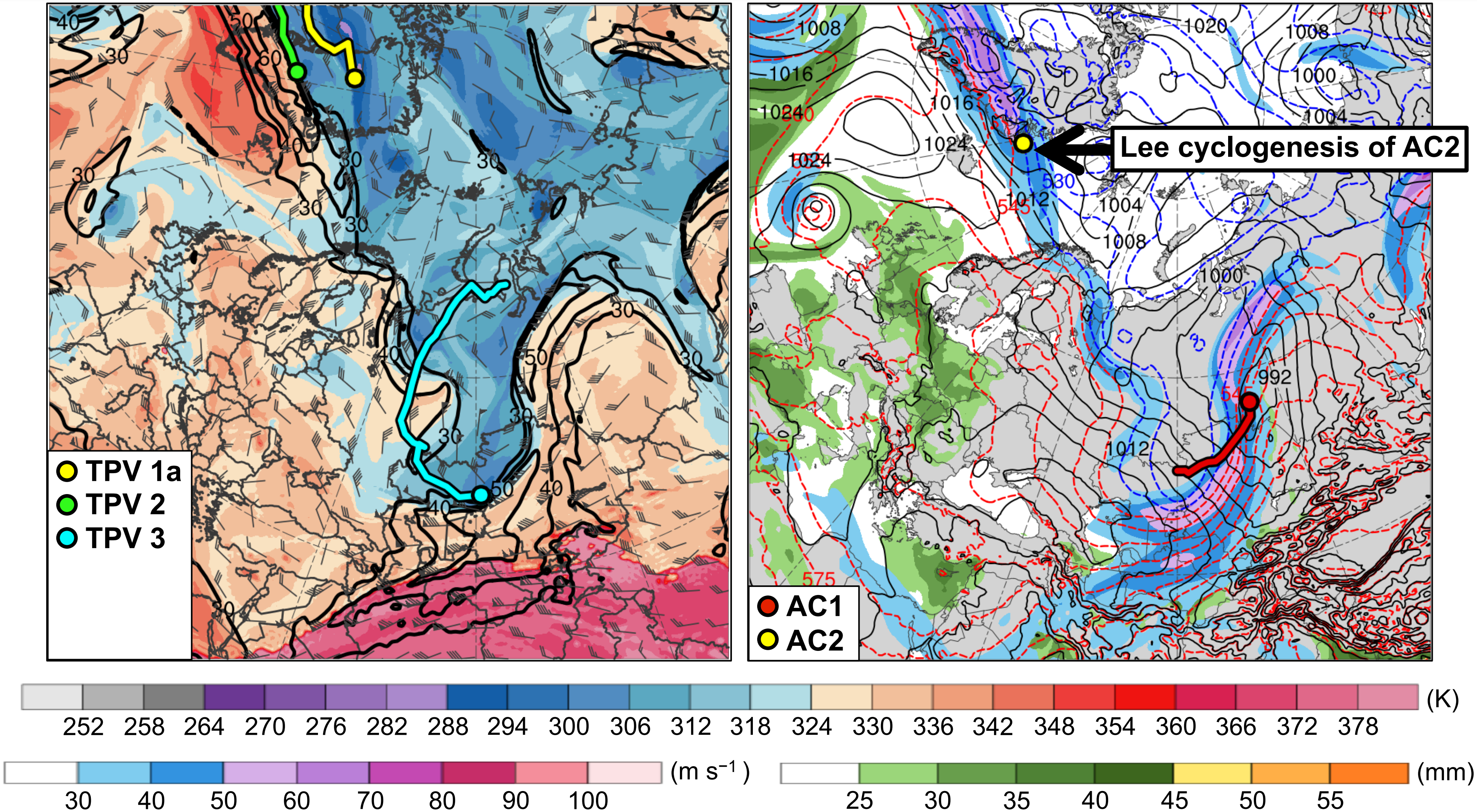
NOAA HYSPLIT 5-d backward trajectories ending at 1200 UTC 2 June 2018

Synoptic Evolution

1200 UTC 2 June 2018



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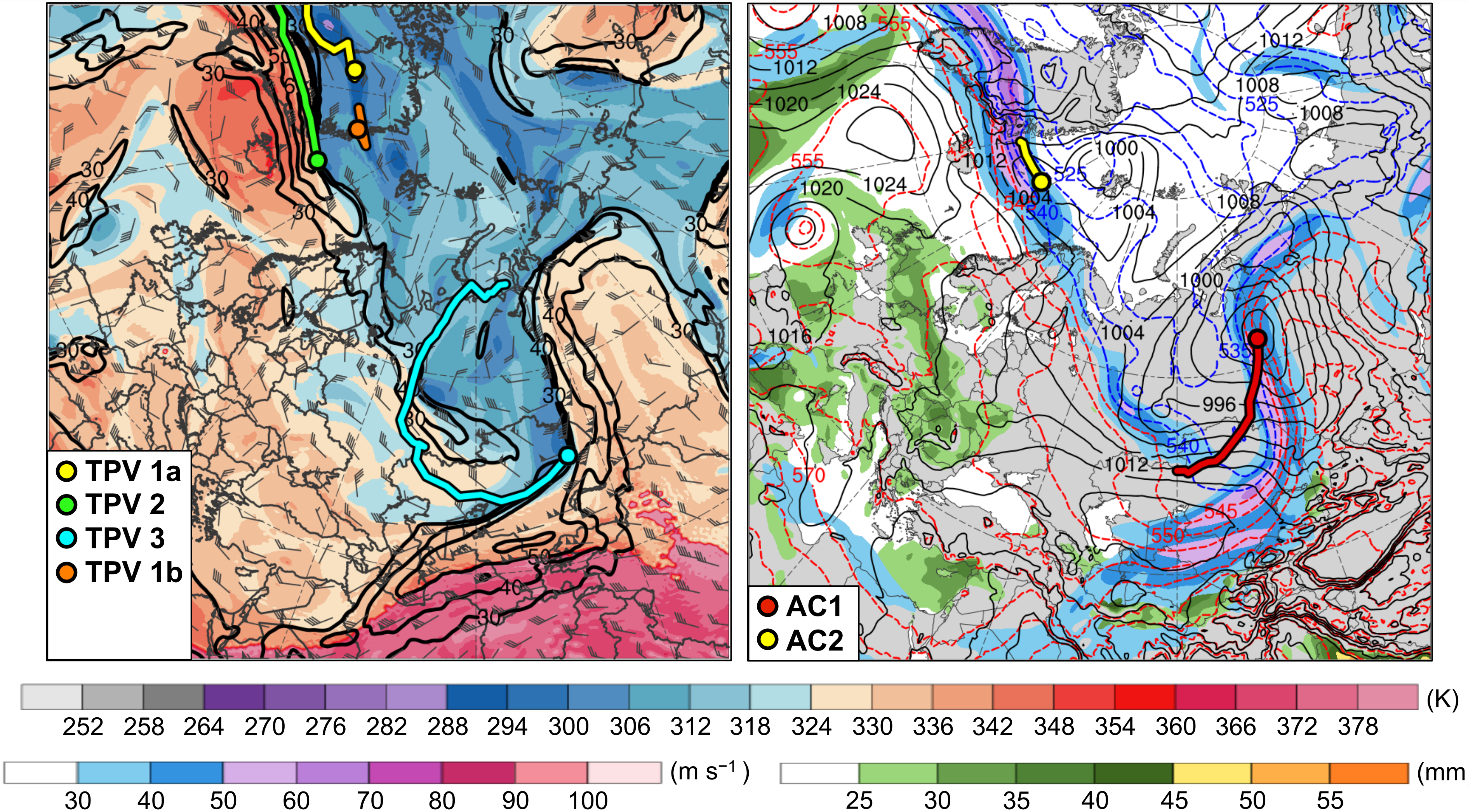
Synoptic Evolution

0000 UTC 3 June 2018



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Synoptic Evolution

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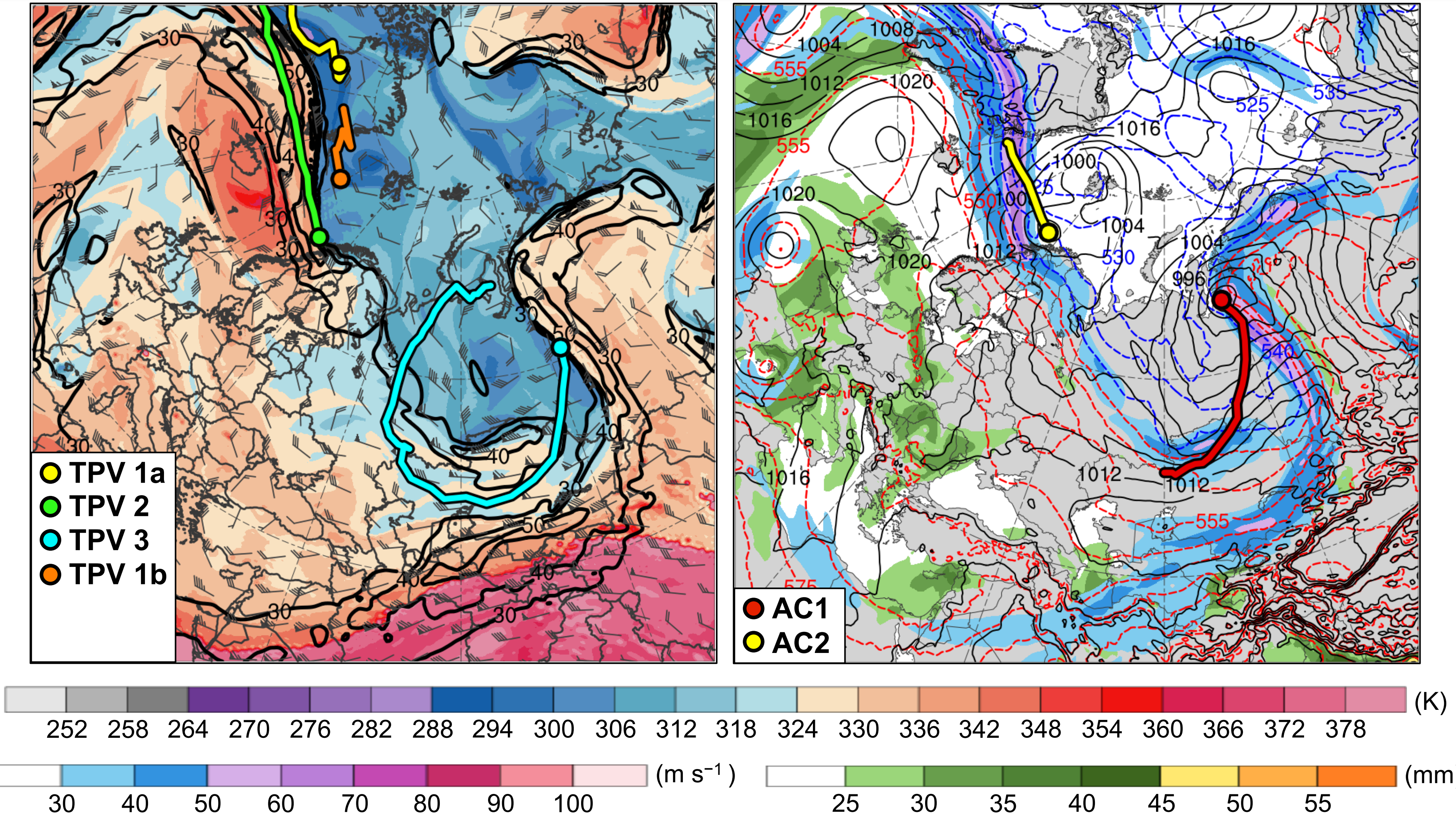

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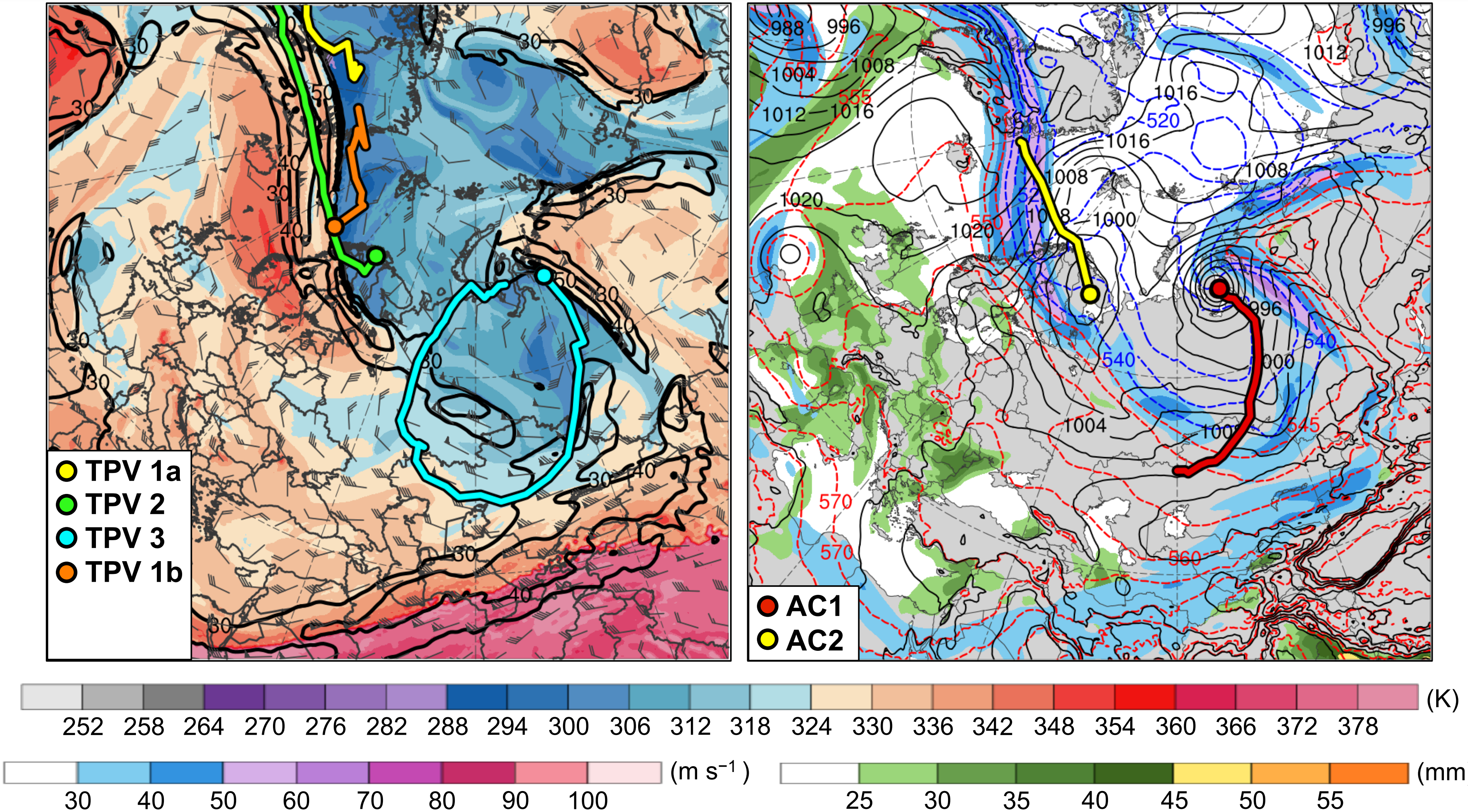
Synoptic Evolution

0000 UTC 4 June 2018



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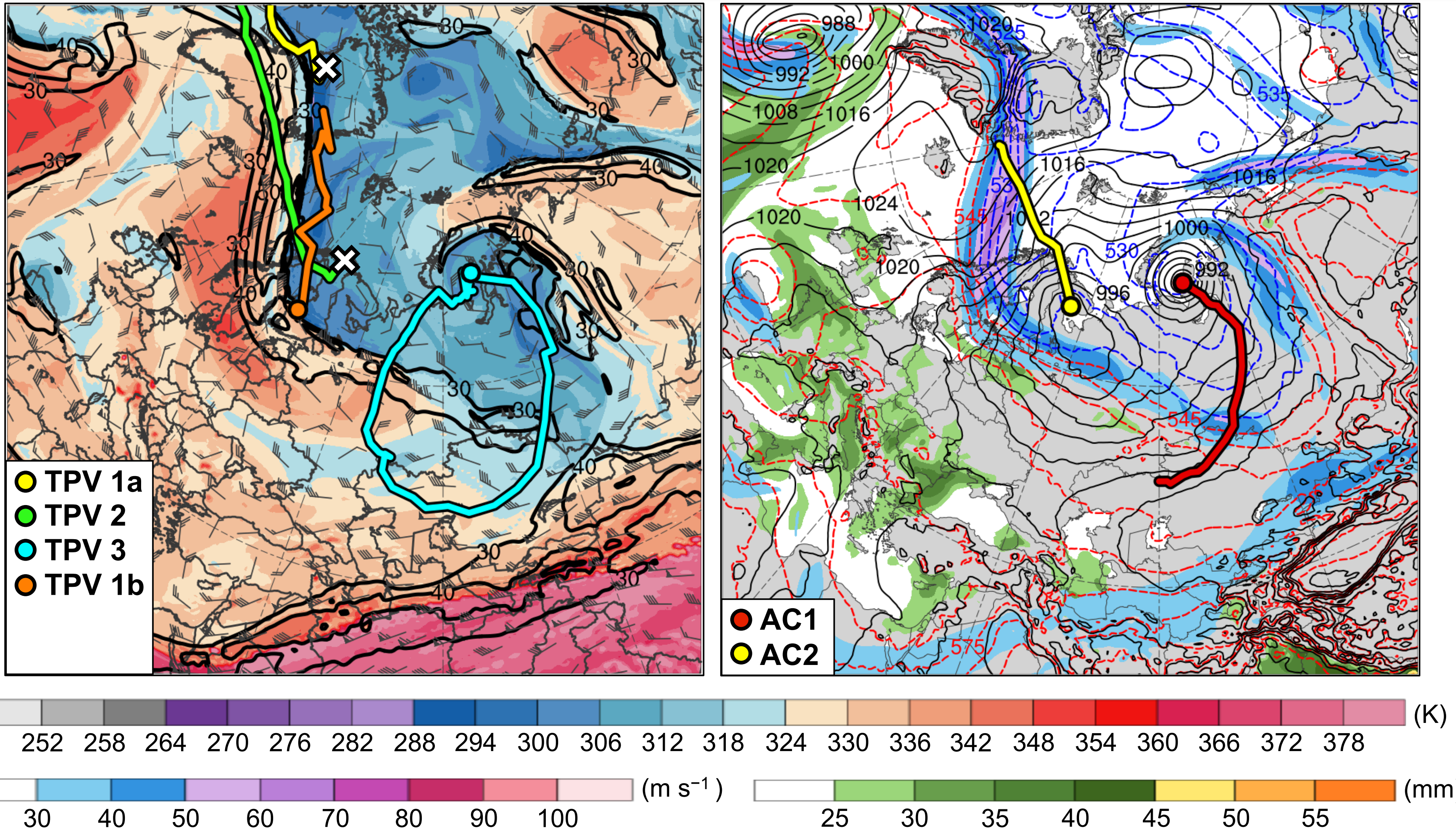

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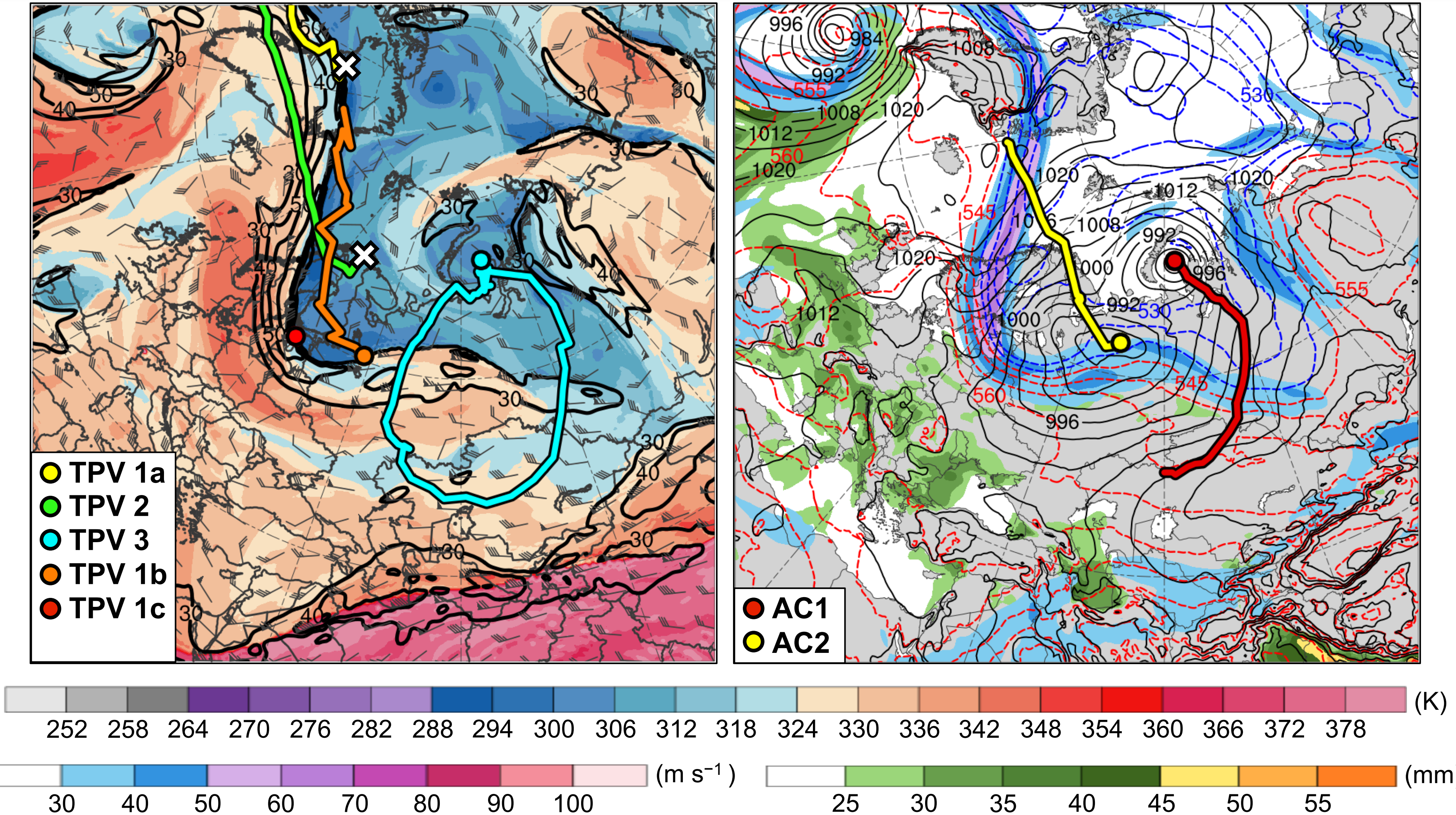
Synoptic Evolution

0000 UTC 5 June 2018



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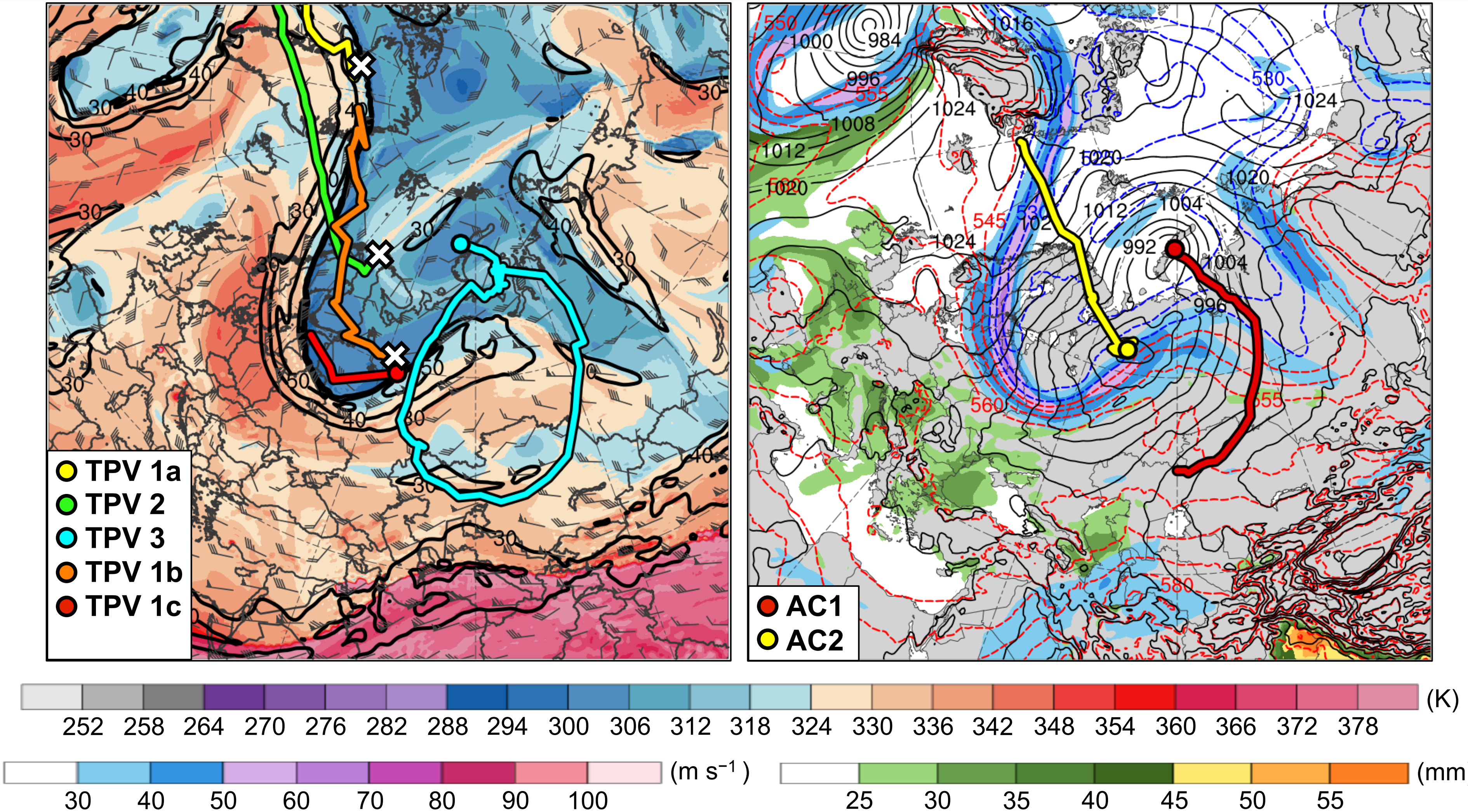

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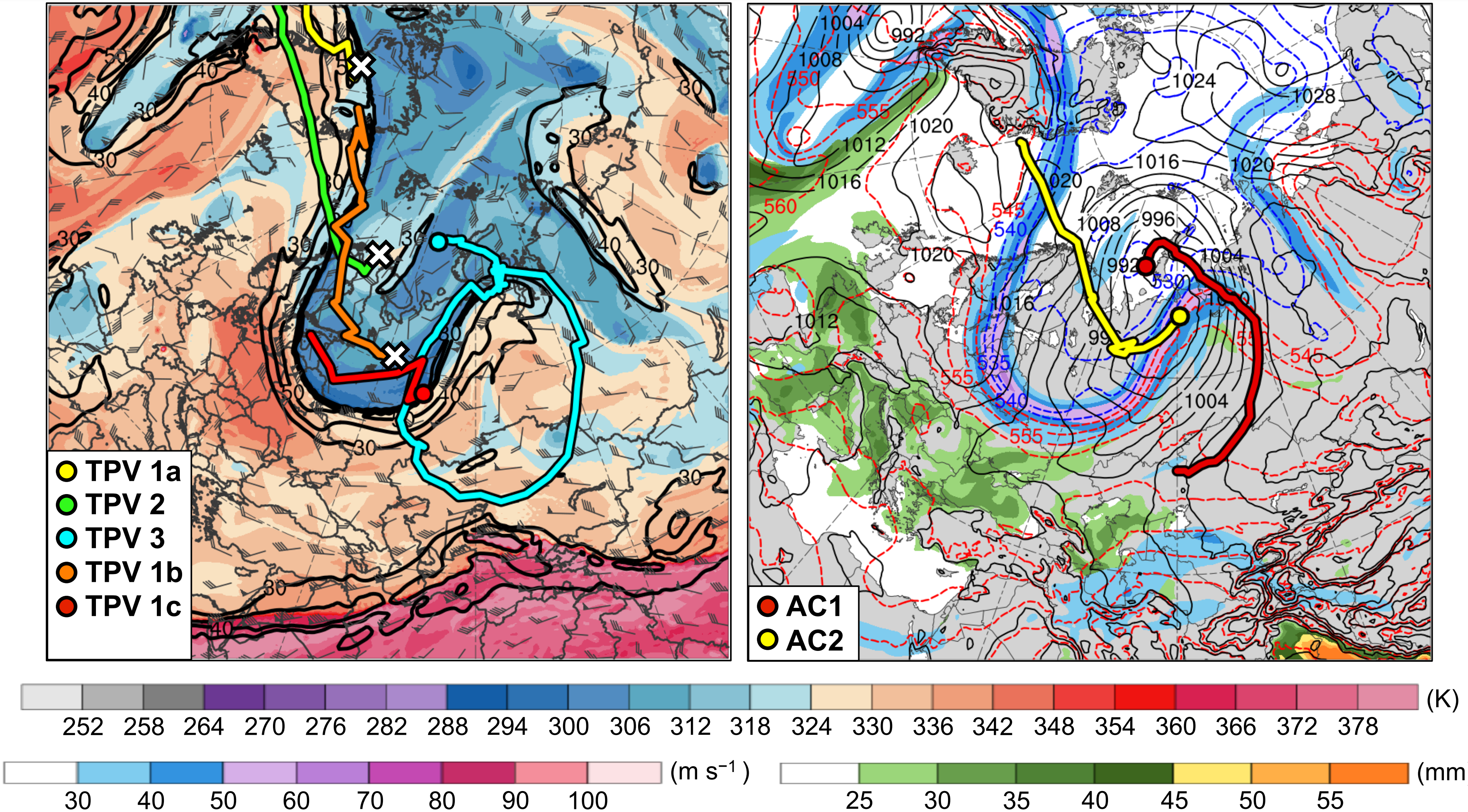

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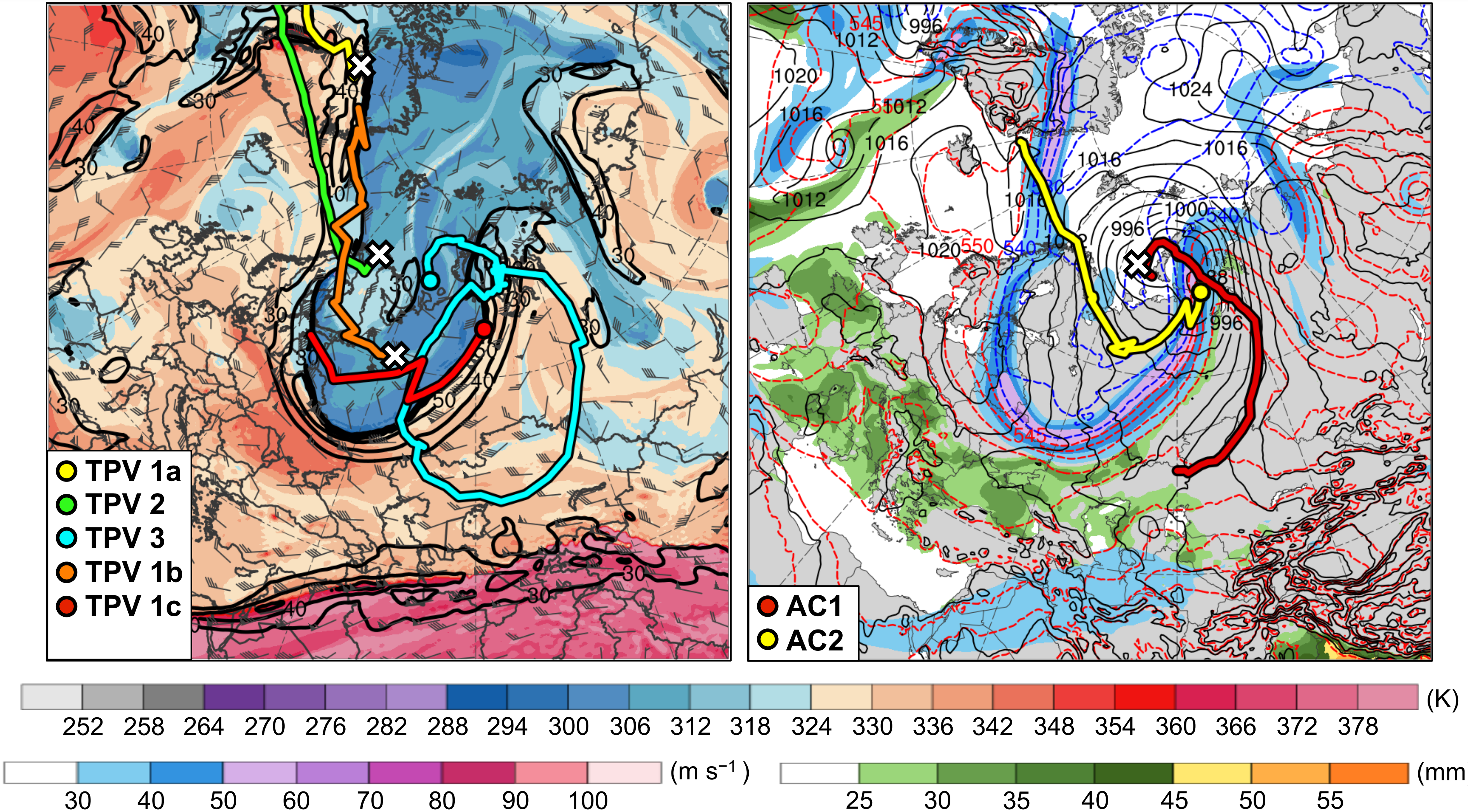

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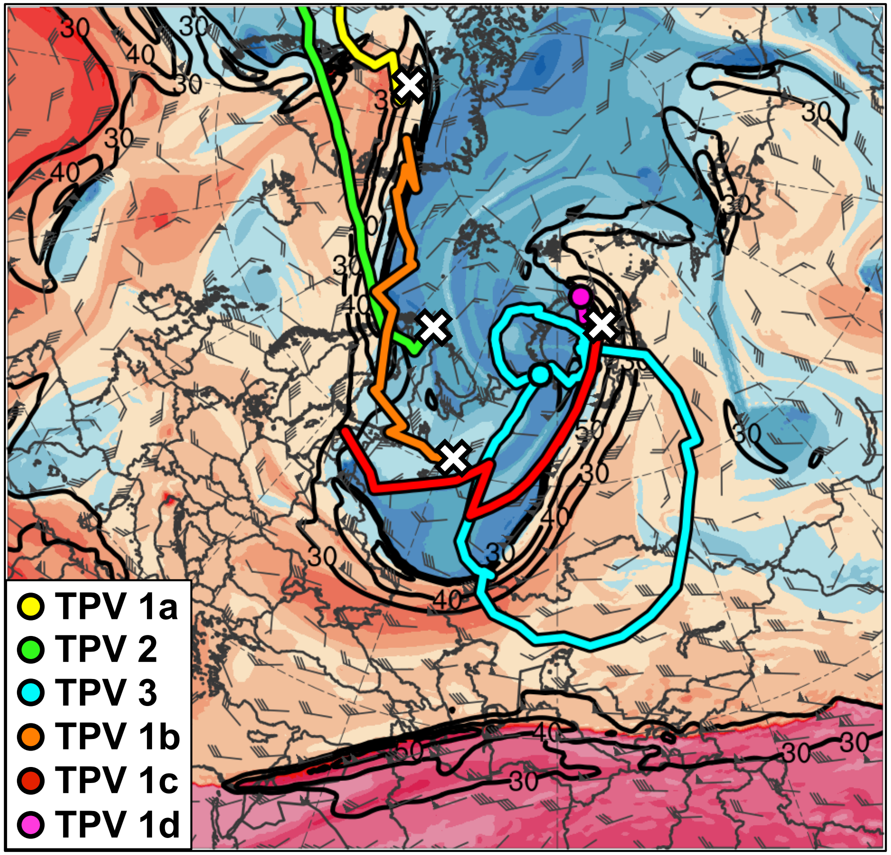

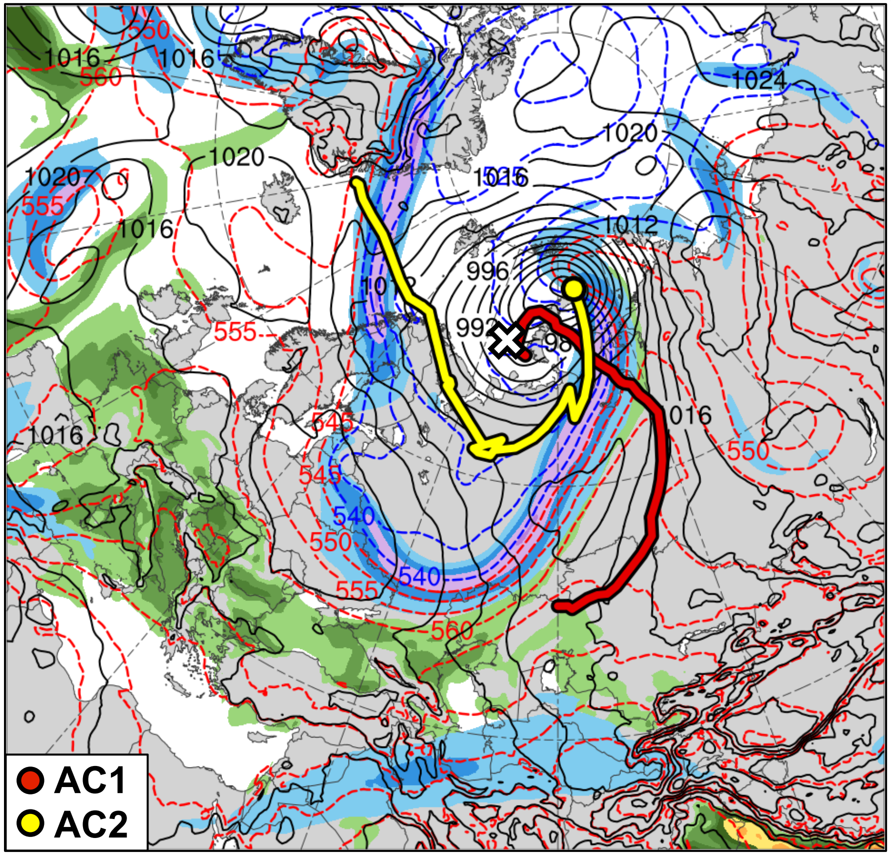

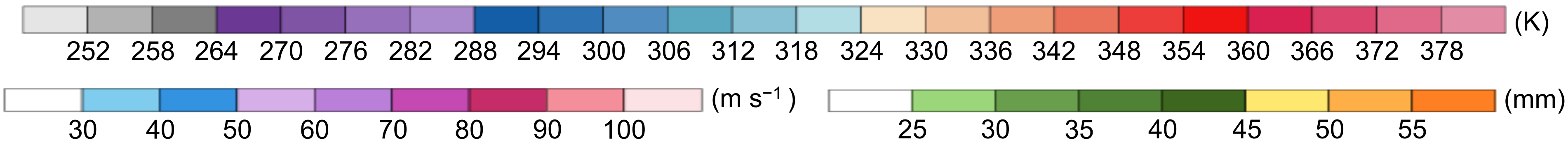

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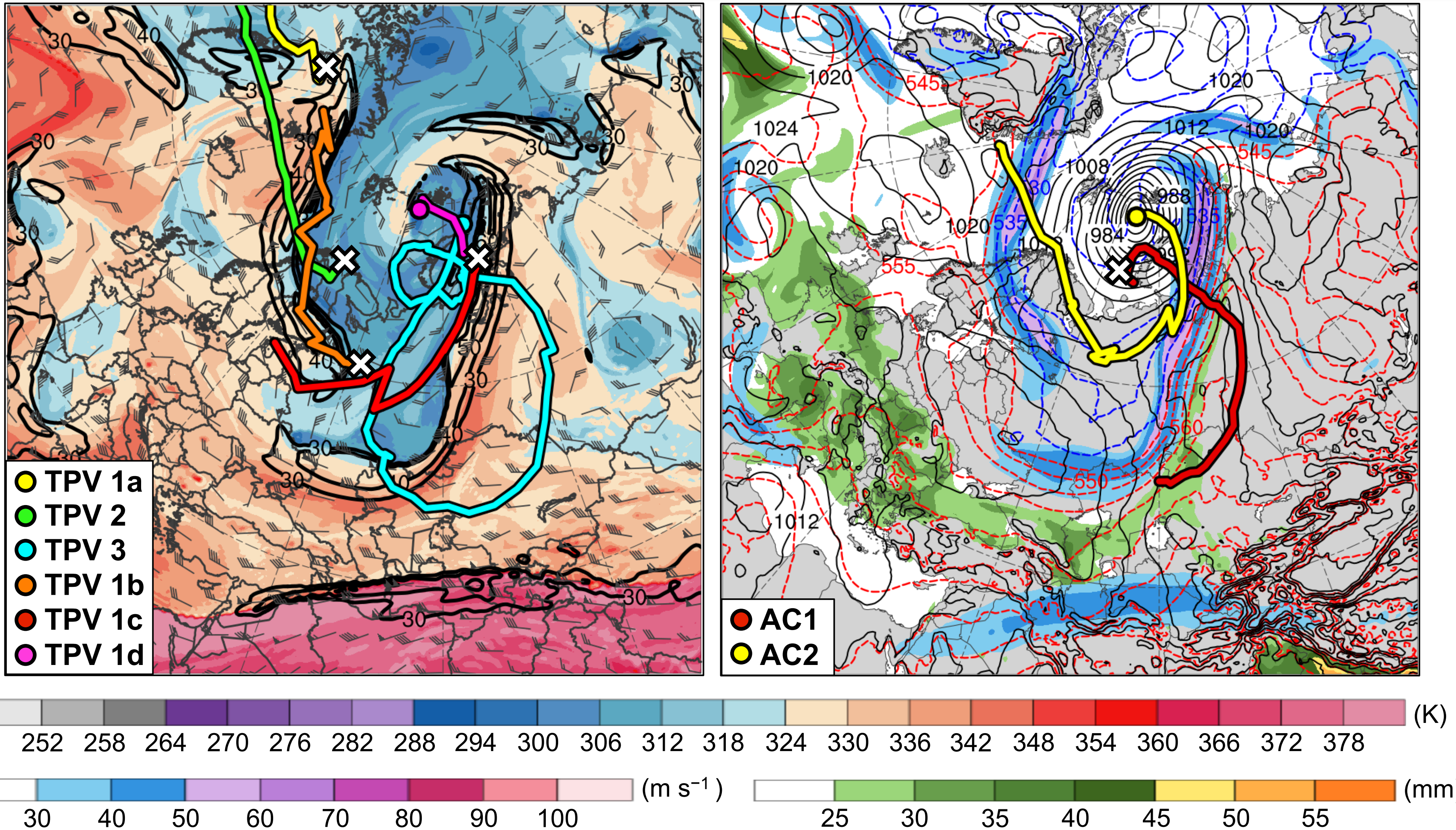

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Conclusions

- AC1 forms within a cold frontal trough near the Caspian Sea
- AC2 forms in the lee of Greenland along a moisture axis accompanying the remnants of TS Alberto, which previously merged with CL

Conclusions

- Both AC1 and AC2 strengthen in a region of strong baroclinicity over western Eurasia ahead of respective high-amplitude upper-level troughs
- Upper-level forcing associated with TPVs embedded within the upper-level troughs and baroclinic processes likely foster the strengthening of AC1 and AC2
- AC2 interacts with and absorbs AC1, becoming the dominant Arctic cyclone with a peak intensity of 962 hPa (SLP standardized anomaly of $< -6\ \sigma$)

Questions? *Email: kbiernat@albany.edu*

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- AC2 interacts with and absorbs AC1, becoming the dominant Arctic cyclone with a peak intensity of 962 hPa (SLP standardized anomaly of $< -6\ \sigma$)