LAGRANGIAN HYDROLOGIC ANALYSIS FOR THE ARCTIC REGION: SOURCE-RECEPTOR RELATIONSHIP AND THE ROLE OF ATMOSPHERIC CIRCULATION

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OBJECTIVE

The proposal of this work is to realize an hydrological characterization for the Arctic region. The origin of the moisture arriving (and then precipitating) in the Arctic is a crucial question in our understanding of the Arctic hydrological cycle. In an attempt to answer this, the present study uses the Lagrangian diagnosis model FLEXPART to localize the main sources of moisture for the Arctic region, to analyze their contribution to precipitation, and to consider the implications of any changes in the transport of moisture from particular sources within the system.

I. METHOD

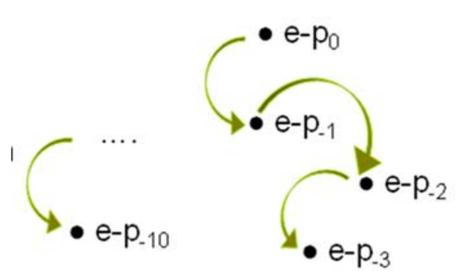
FLEXPART v9.0 model + meteorological reanalysis data ERA-Interim from ECMWF

The atmosphere is divided homogeneously in a large number of particles (2 million) with the same constant mass m

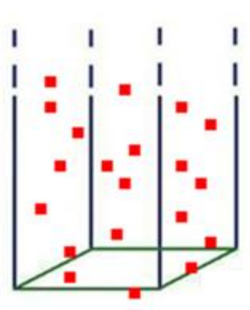
every 6 hours with a 1ºx1º resolution on 60 vertical levels (14 model levels below 1500m)

The increases (e) and decreases (p) in moisture along the trajectory can be calculated through changes in (q) with the time:

$$e - p = m\frac{dq}{dt}$$



When adding (e-p) for all the particles residing in the atmospheric column over an area, we can obtain (E-P), that is, the surface freshwater.



$$E - P \approx \frac{\sum_{k=1}^{K}(e-p)}{A}$$

The particles were recorded every 6 hours and the tracks were calculated limiting the transport times to 10 days.

E → evaporation
P → precipitation
K → nº particles

II. EXPERIMENT

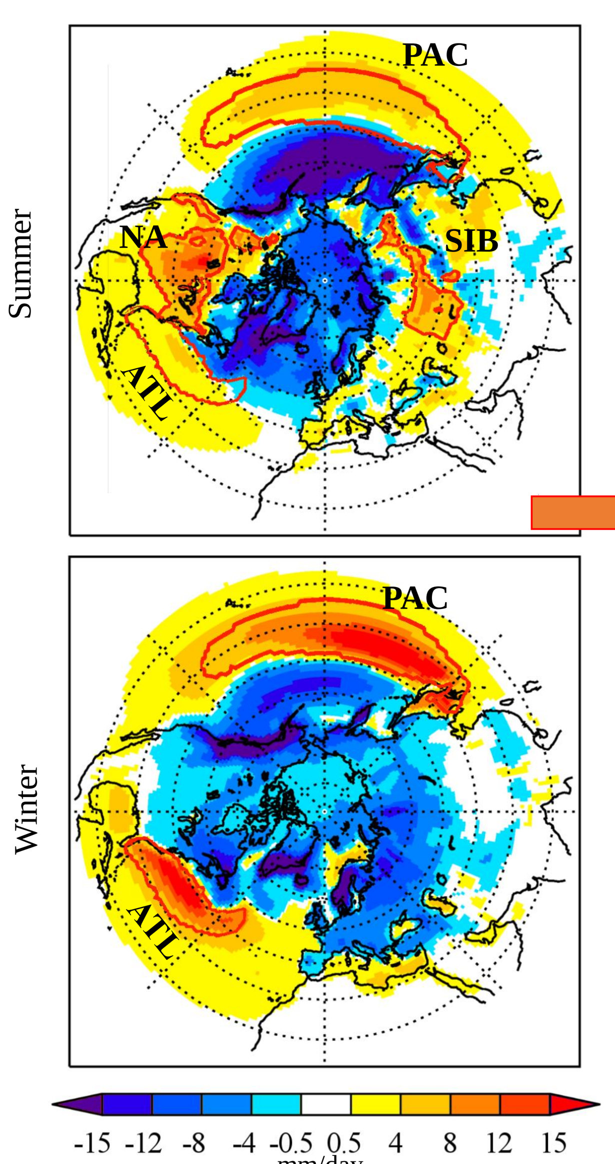
To localize moisture sources for the system, trajectories of particles reaching the Arctic for every day on the period 1980-2012 were follow **BACKWARD** in time. From this analysis it is possible to identify those areas where particles gains moisture (e-p)>0. Considering every particle and calculating E-P for every grid area, **sources of moisture** correspond with areas showing **positive (E-P) values**.

For located sources particle trajectories can be followed **FORWARD** in time to analyze their moisture contribution into the system. So, we are interested in those areas where **E-P is negative** from the source (**SINK areas**, where particles lose moisture).

From both analysis is possible to investigate the variability on moisture and its contribution to Arctic hydrological cycle. Atmospheric circulation have an important influence on moisture contribution from sources, because of this fact the influence of NAO and PNA was investigate for major source contribution at interannual and daily scale. At daily scale, moisture contributions from Pacific and Atlantic were investigated by forward analysis for those days showing a value greater than 1 on PNA and NAO index, respectively. At interannual scale a correlation analysis was done.

III. RESULTS

A) Sources identification (backward)



Main sources of moisture for Arctic system:

- **Oceanic (all seasons):**
  - **Pacific Ocean (PAC)**
  - **Atlantic Ocean (ATL)**
- **Continental (Summer):**
  - **Siberia (SIB)**
  - **North America (NA)**

B) Moisture contribution from main sources (forward)

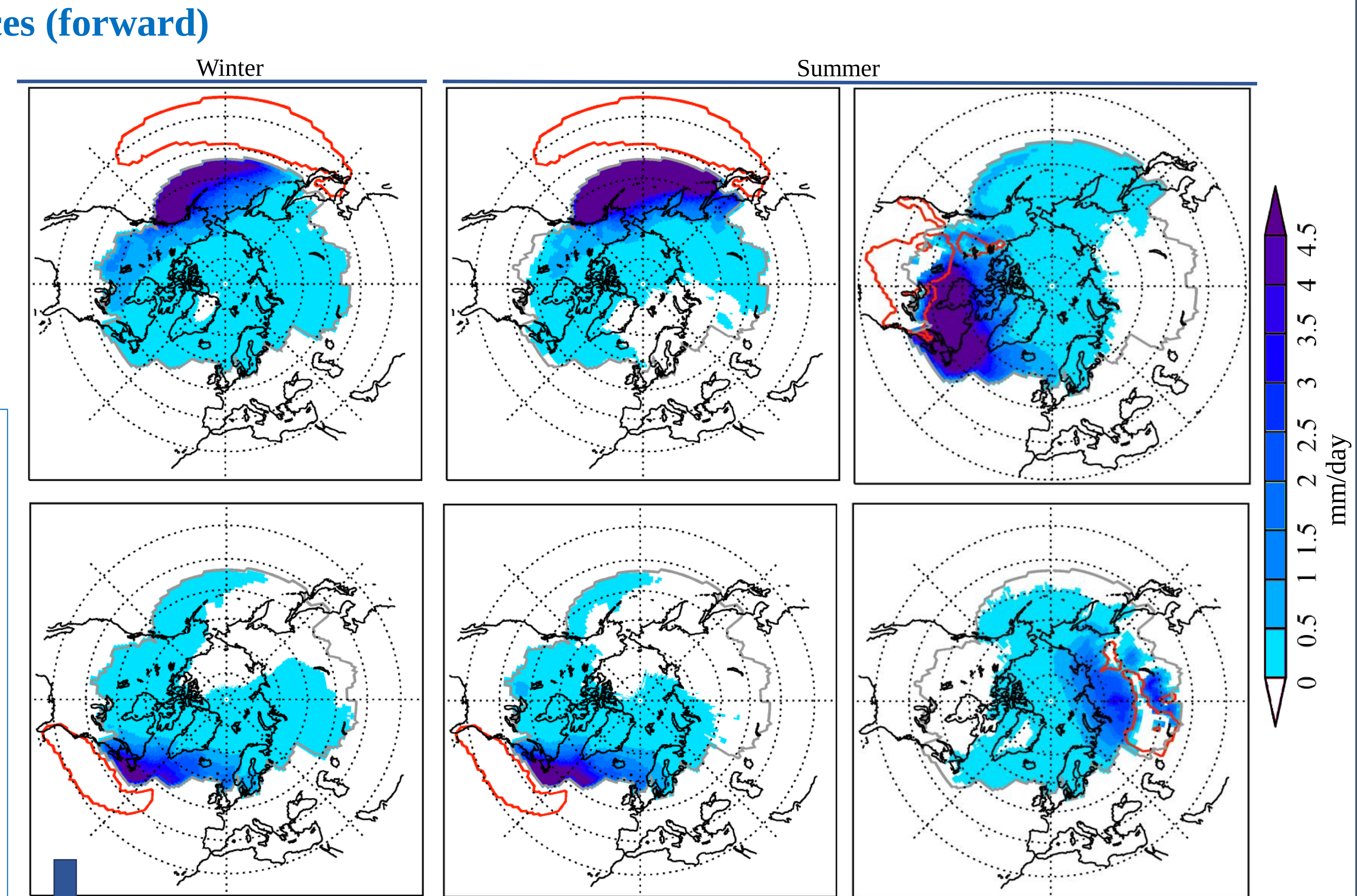
	Spring	Summer	Fall	Winter
ATL	3154.95	3478.37	**4071.99**	3140.18
PAC	7081.58	**11774.80**	7906.81	6363.84
NA		8794.73		
SIB		5378.51		

Measured in mm/day

- PAC shows its maximum contribution on Summer, and ATL in Autumn.

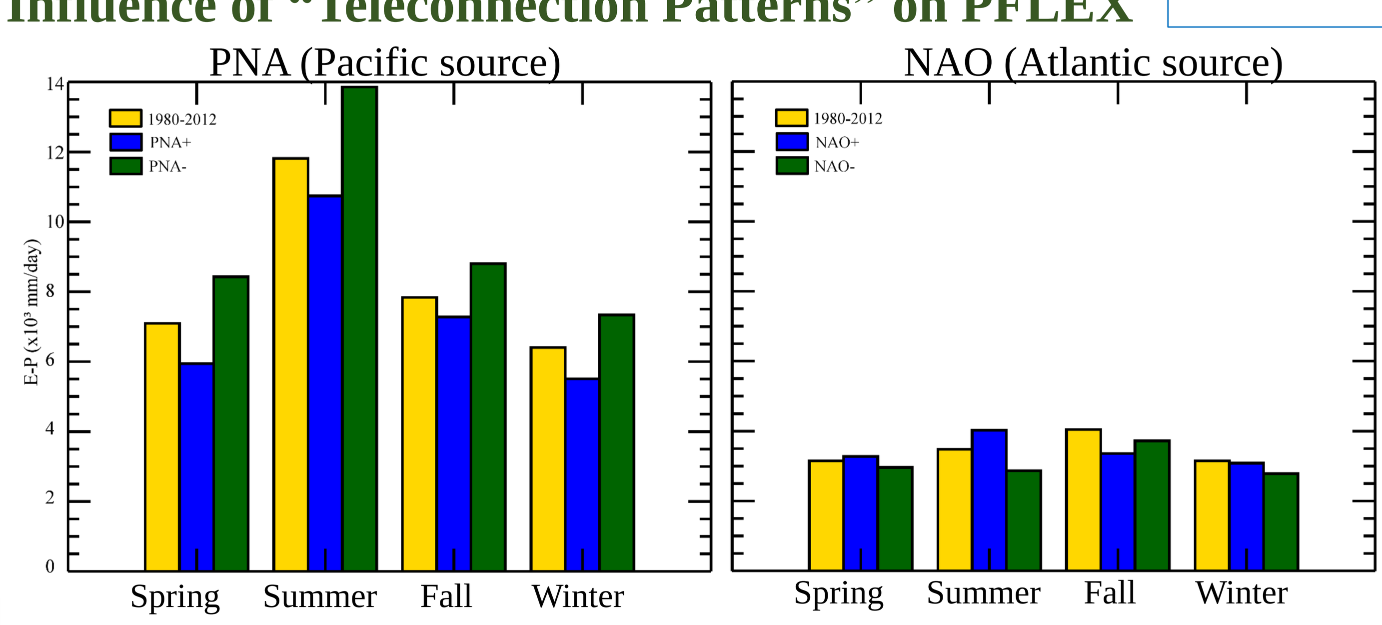
- Both sources (PAC and ATL) have minimum contribution on Summer.

- PAC is the source providing most of the moisture supply.



Moisture contribution (PFLEX) over Arctic system occurs northeast of the sources. The area of influence of oceanic sources is similar for every season.

C) Influence of "Teleconnection Patterns" on PFLEX



"Daily scale":

- **PNA- : PFLEX increases over the Arctic system from PAC**
- **PNA+ : PFLEX decreases for every season from PAC**
- **NAO : the influence not clear over the moisture from ATL**

Interannual scale:

- **PNA : negative significant correlation between index and anomalous PFLEX from PAC source**
- **NAO : not significant correlation for ATL source**

correlations	Spring	Summer	Fall	Winter
PNA	-0.544*	-0.493*	-0.319*	-0.676*
NAO	0.279	0.259	-0.173	0.161

*Significant at 90%

CONCLUSIONS

About sources and sinks:

Four major sources were identified for the Arctic region: subtropical and southern extratropical **Atlantic** (ATL) and **Pacific Oceans** (PAC), **North America** (NA) and **Siberia** (SIB).

- **ATL and PAC** appear as dominant sources with an **influence along all the year** (maximum in winter).
- In **summer** they appear weakened and **NA and SIB** (the continental sources) gain in importance.

Each moisture source has been shown to **have a different area of influence over the system**, **mostly** to the **northeast of the source itself**.

Moisture supply for oceanic sources show **greater** values **in summer** than in winter.

PAC is the **most important** source for **every season**.

About relation with teleconnection patterns:

Moisture supply over the Arctic has been shown to be **slightly influenced by teleconnection patterns**.

- In the case of PAC source: PNA seems to have an **important influence on moisture contribution** (PFLEX), the same signal was found **on interannual and daily analysis**, being its negative phase associated with increased moisture supply from the source.
- In the case of ATL: no significant correlation was found with NAO.

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