AMSTer : SAR & InSAR Automated Mass processing Software for Multidimensional Time series

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- Optional module for MasTer Toolbox -

Optimised pair selection

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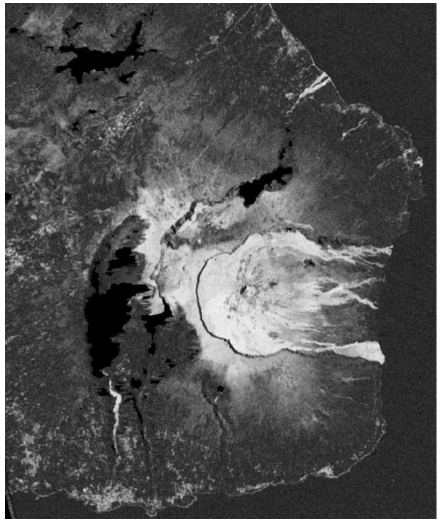
[1] European Center for Geodynamics and Seismology, Luxembourg (delphine@ecgs.lu)

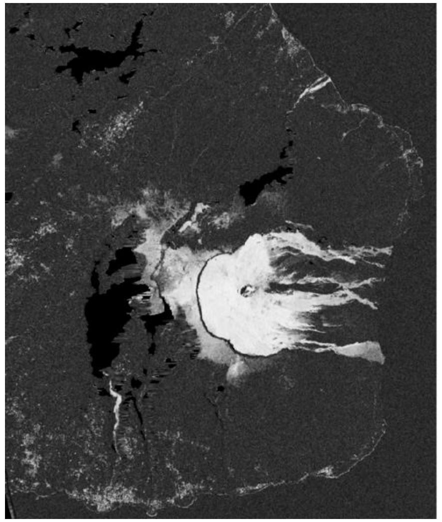
Pair Selection Principle in AMSTer Toolbox

User need to chose BT_{max} and BP_{max}

Short baselines = better coherence



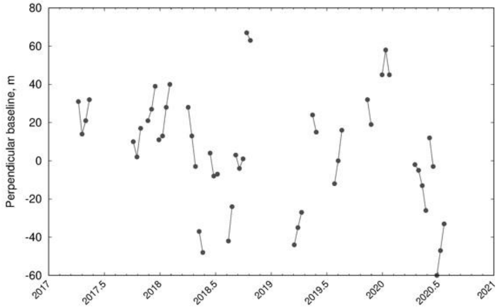
BT = 12 days



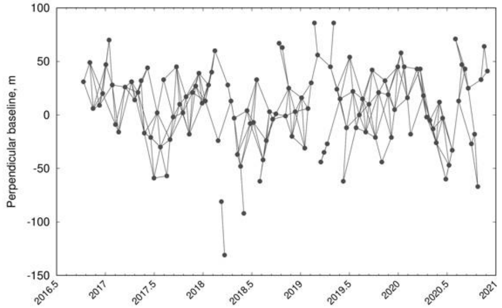
BT = 72 days

Long baselines = better connectivity

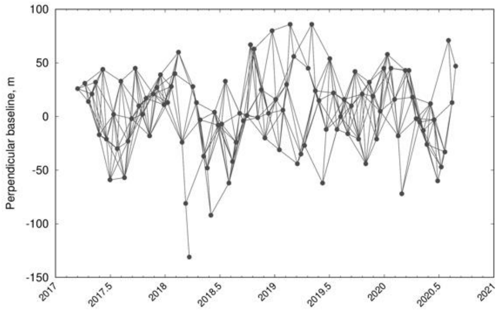
BT_{max} = 20 days ; BP_{max} = 20m



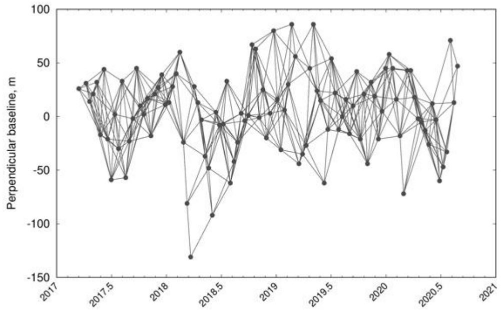
BT_{max} = 50 days ; BP_{max} = 50m



BT_{max} = 70 days ; BP_{max} = 70m



BT_{max} = 75 days ; BP_{max} = 75m



User need to chose BT_{max} and BP_{max}

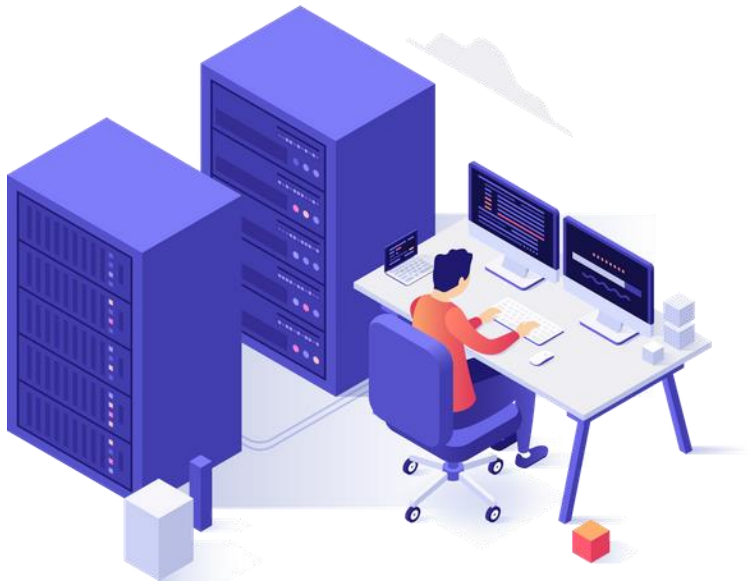
Best compromise depends on :

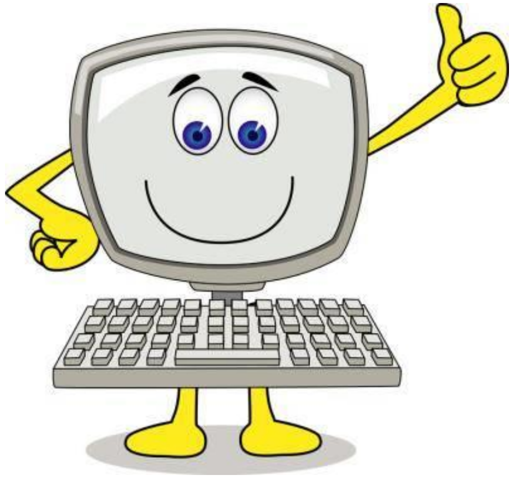
- Area characteristics
- Satellite orbits characteristics
- Expected displacement velocity

And also :

- Computational resources
- Storage resources

While working with :
- Larger and larger databases
- Limited computer resources





Optimization aims at :
- Saving computation time
- Saving storage resources
- Improve ? / Not degrade results

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Optimization Principle

List of SAR acquisitions (*AMSTer inputs*) => Prepa_msbas.sh

⇒ List of interferograms to compute => SAR_MASS_Processing

⇒ List of deformation maps to invert => MSBAS

⇒ Time series (*AMSTer final products*)

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Optimization Principle

List of SAR acquisitions (*AMSTer inputs*) => Prepa_msbas.sh

⇒ List of interferograms to compute => SAR_MASS_Processing

Option 1

⇒ List of deformation maps to invert => MSBAS

Option 2

Remove from the list

⇒ Time series (*AMSTer final products*)

Optimization Principle

List of SAR acquisitions (*AMSTer inputs*) => Prepa_msbas.sh

⇒ List of interferograms to compute => SAR_MASS_Processing

Option 1

⇒ List of deformation maps to invert => MSBAS

Option 2

Remove from the list

⇒ Time series (*AMSTer final products*)

Additional constraints :

⇒ Keep sufficient graph connectivity

⇒ Remove poor quality interferograms

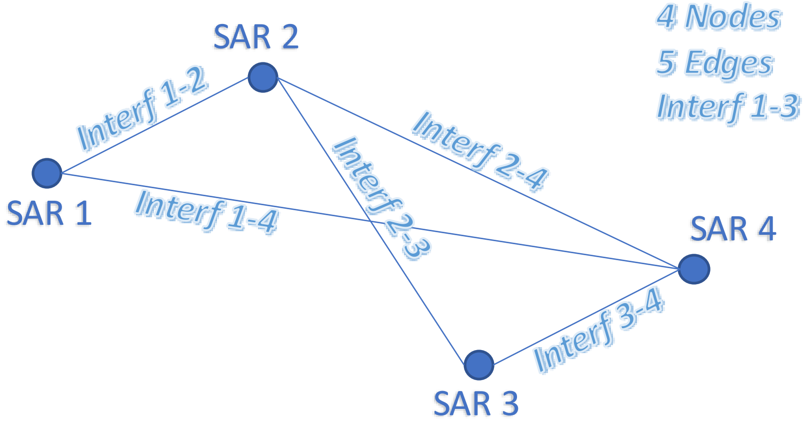
⇒ Use each image as often as primary and as secondary image

A Graph Framework

Baseline Plot = Graph

SAR acquisitions = **nodes**

Interferograms = **edges**

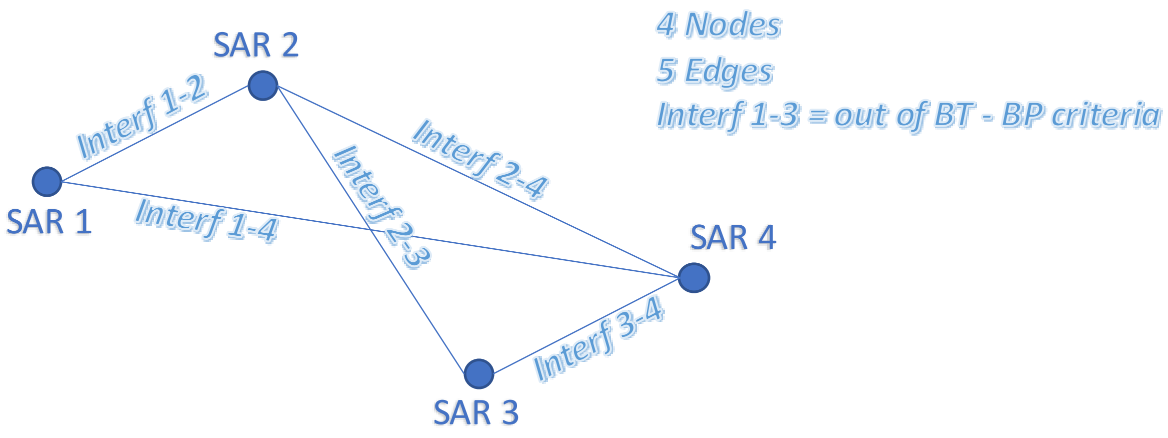


4 Nodes

5 Edges

Interf 1-3 = out of BT - BP criteria

A Graph Framework



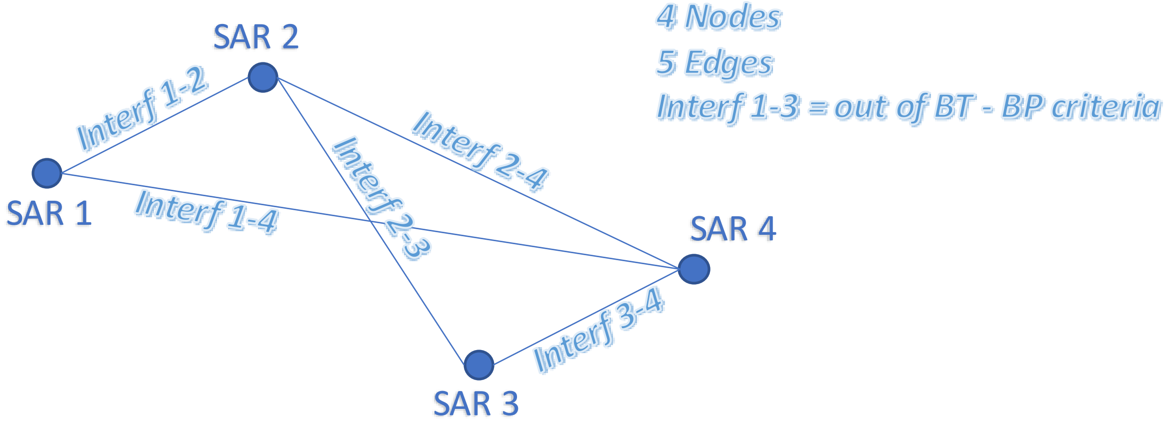
Baseline Plot = Graph
SAR acquisitions = **nodes**
Interferograms = **edges**

Node Degree = number of connected neighbors

example : SAR 2 : degree 3
SAR 3 : degree 2

A Graph Framework

Baseline Plot = Graph
SAR acquisitions = **nodes**
Interferograms = **edges**



Graph is oriented : Node In-degree = number of incoming connections
Node Out-degree = number of outcoming connections
example : SAR 2 : In-degree 1 – Out-degree 2
SAR 3 : In-degree 1 – Out-degree 1

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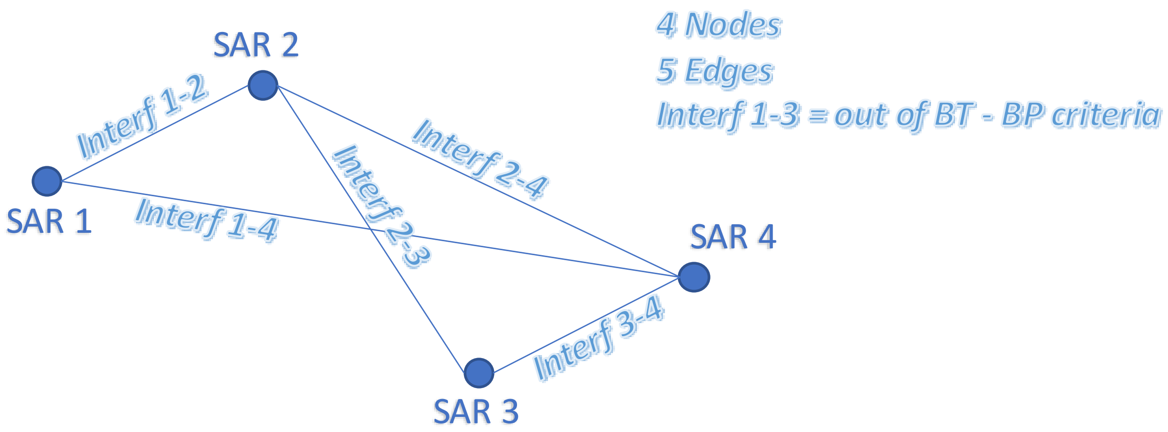
A Graph Framework



Baseline Plot = Graph

SAR acquisitions = **nodes**

Interferograms = **edges**

Optimization

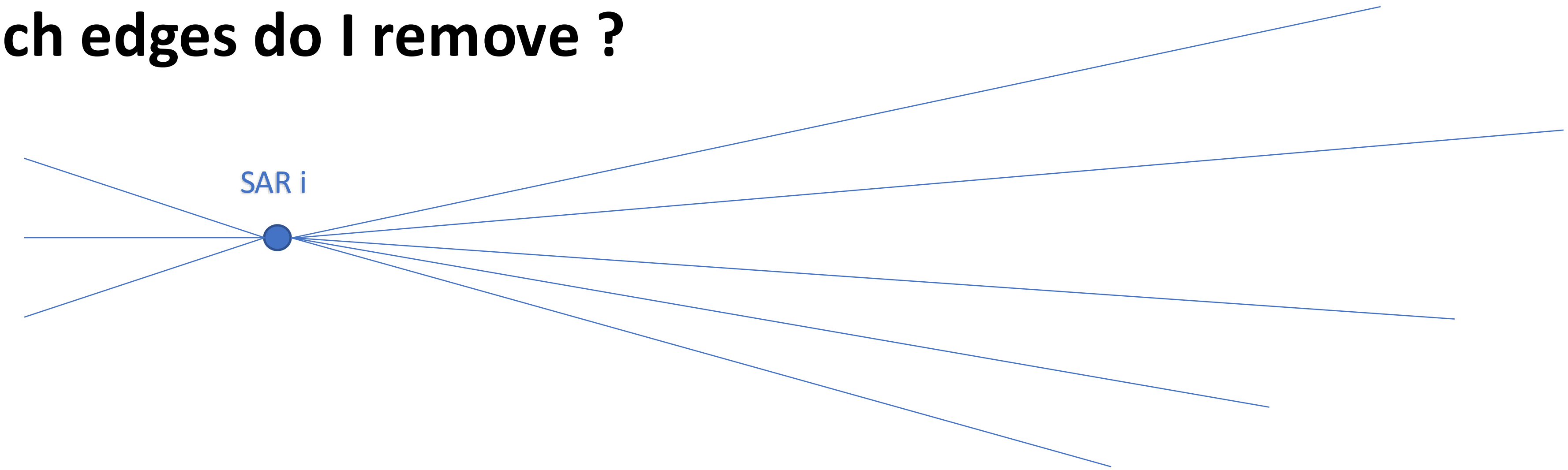
⇒ Same In-degree and Out-degree for all node : k

⇒ Find a subgraph by removing non-necessary edges

I chose k=3

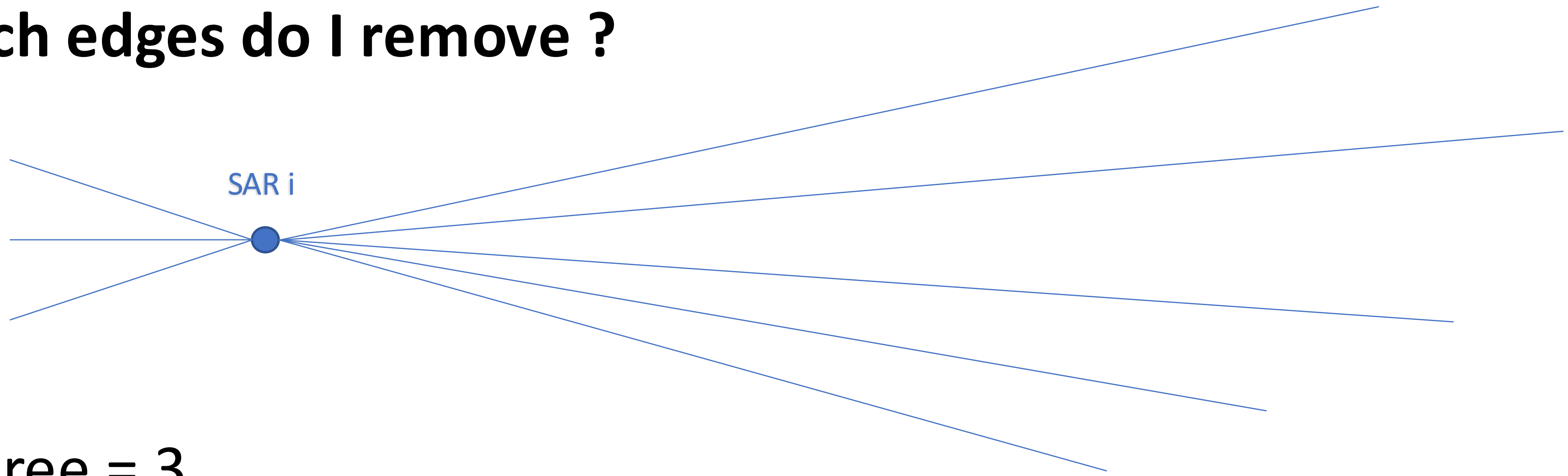
I chose k=3

Which edges do I remove ?



I chose k=3

Which edges do I remove ?



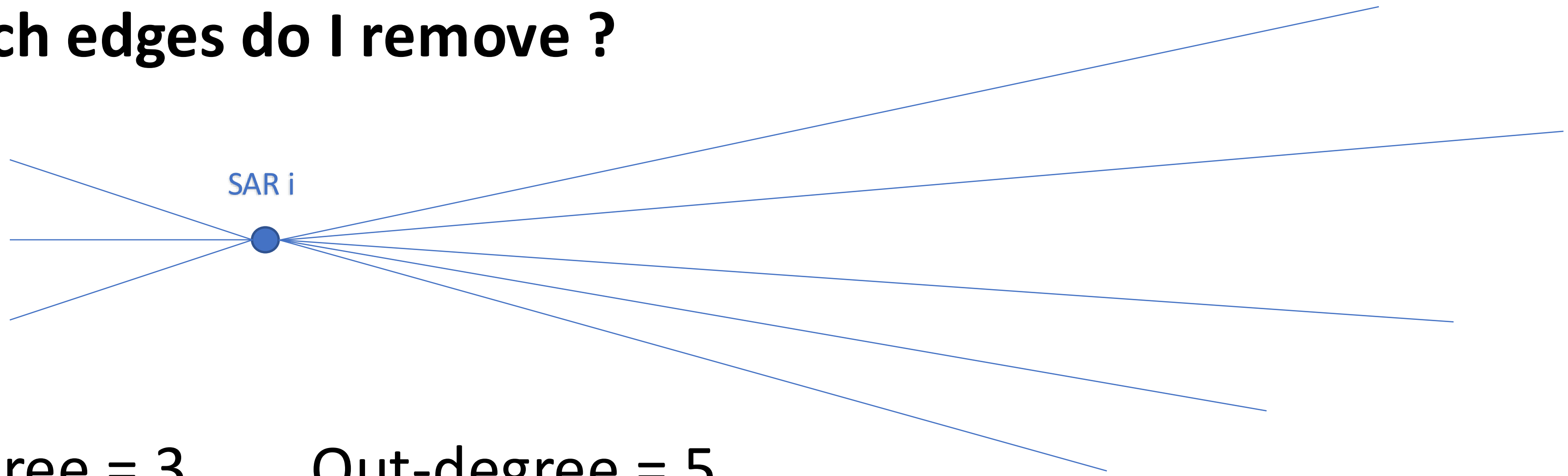
In-degree = 3

3=k

OK

I chose k=3

Which edges do I remove ?



In-degree = 3 Out-degree = 5

3=k 5>k

OK Remove 2 edges…

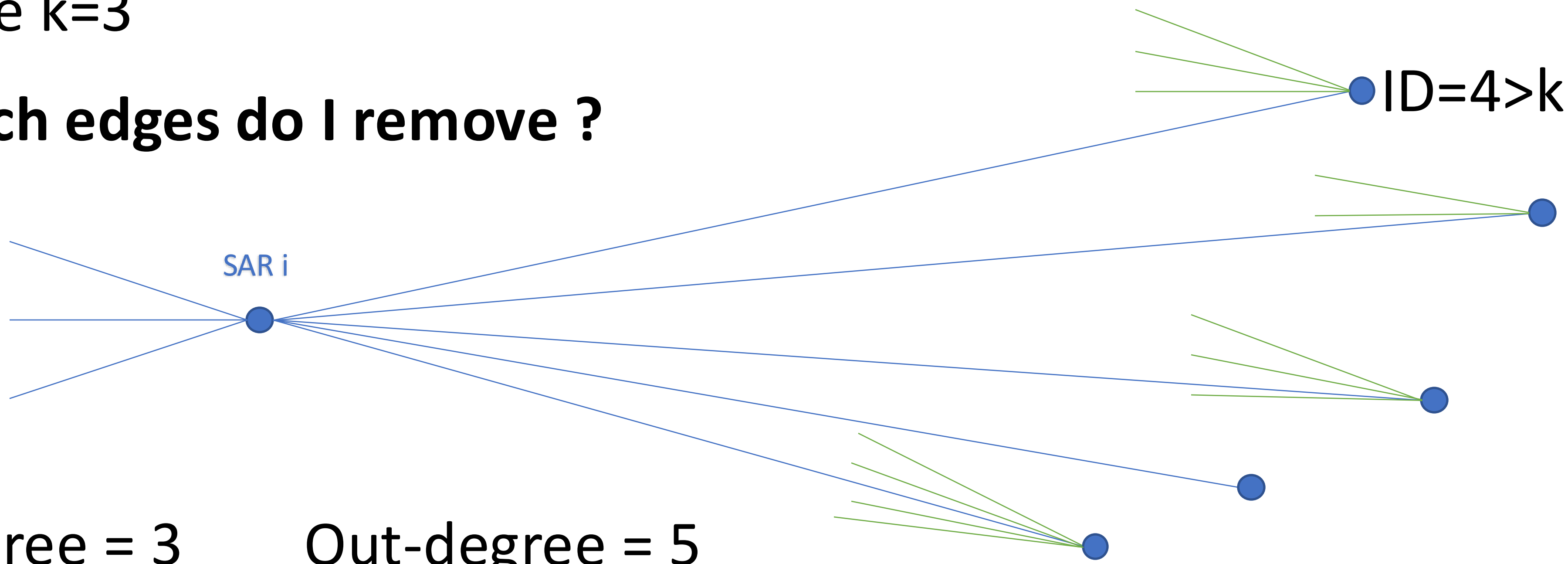
A Graph Framework

I chose k=3

Which edges do I remove ?

Removable ?

YES



In-degree = 3
3=k
OK

Out-degree = 5
5>k
Remove 2 edges…

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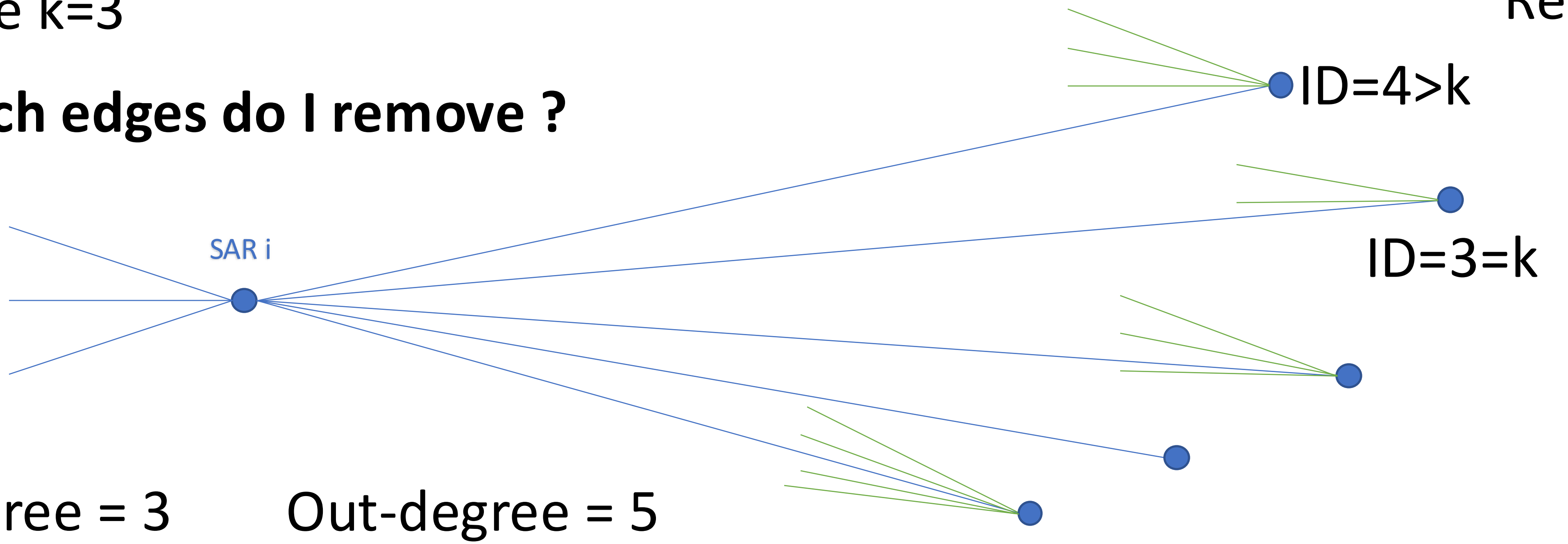
A Graph Framework

I chose k=3

Which edges do I remove ?

Removable ?



YES

No

In-degree = 3

3=k

OK

Out-degree = 5

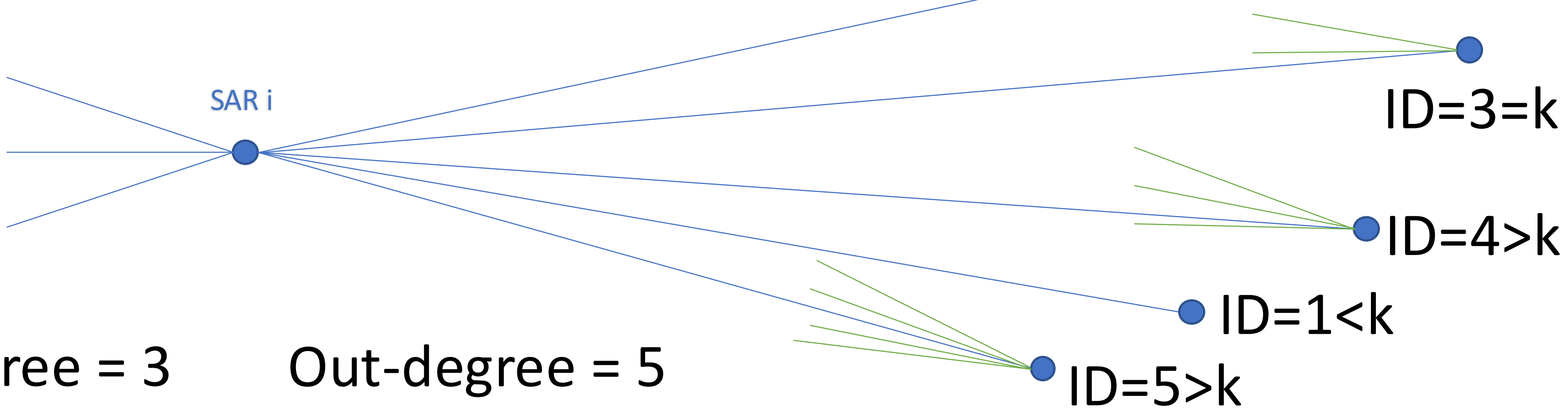
5>k

Remove 2 edges…

A Graph Framework

I chose k=3

Which edges do I remove ?



Removable ?

YES

No

YES

No

YES

In-degree = 3

3=k

OK

Out-degree = 5

5>k

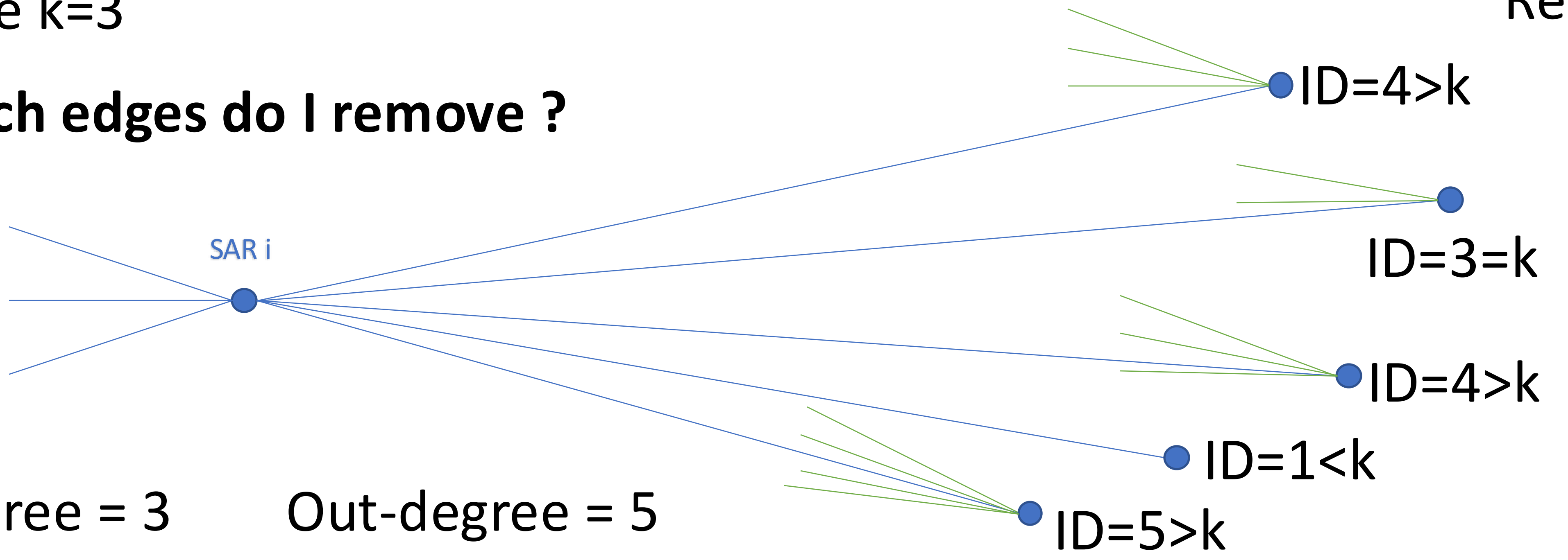
Remove 2 edges…

… among 3 removable

A Graph Framework

I chose k=3

Which edges do I remove ?



Removable ?

YES

No

YES

No

YES

In-degree = 3

3=k

OK

Out-degree = 5

5>k

Remove 2 edges…

… among 3 removable

=> Need for an additional criteria

Weighted Graph

Give a weight to each edge

⇒ Sort removable edges

⇒ Remove edge with the lowest weight

	Coherence	Coherence Proxy
Advantages	Remove in priority the poorly coherent interferograms	No need to compute the coherence of all possible pairs
Inconvenient	Need to compute the coherence of each pair	Need correct calibration

Algorithm workflow

1) Create an oriented graph
2) Compute weight of each edge
3) Compute in-degree and out-degree of each node

4) For each node:
    5) Compute number of edges to remove
    If needed :
        6) Compute number of removable edges
        If possible :
            7) Sort removable edges according to their weight
            8) Remove edges
            9) Update nodes' degrees
        end
    end
End

10) Save optimized list of edges

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Coherence proxy

3 main causes of coherence loss

- Temporal decorrelation => w_2
- Spatial decorrelation => w_3
- Seasonal decorrelation=> w_1

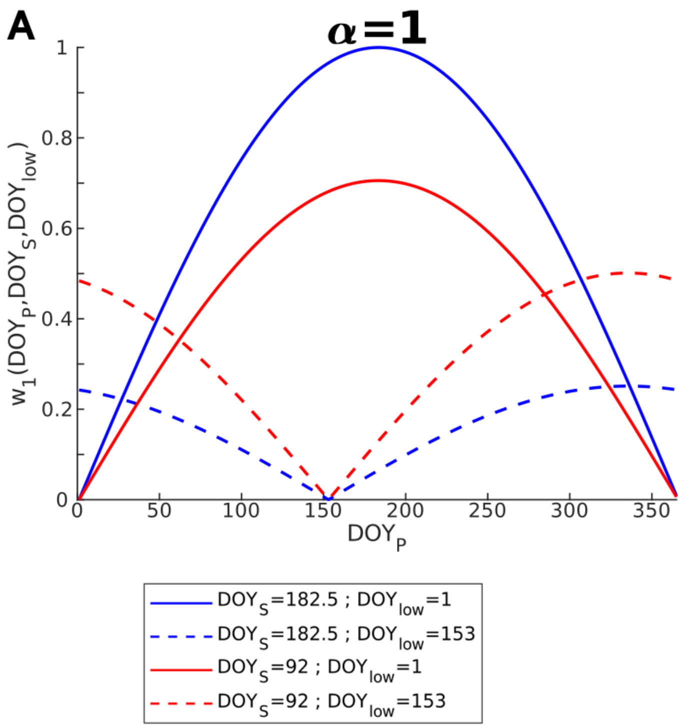
$$w = a\, w_1 + b\, w_2 + c\, w_3$$

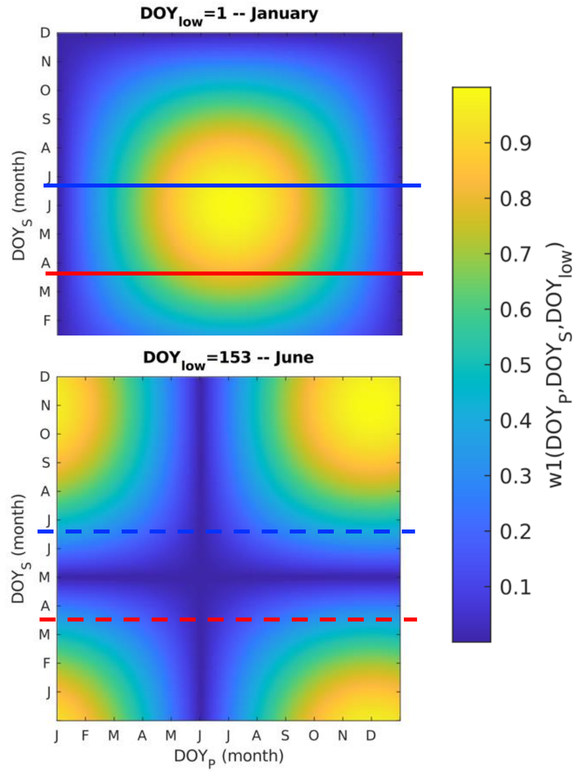
a, b and c are inverted using a calibration subset of coherence values for a list of pairs.

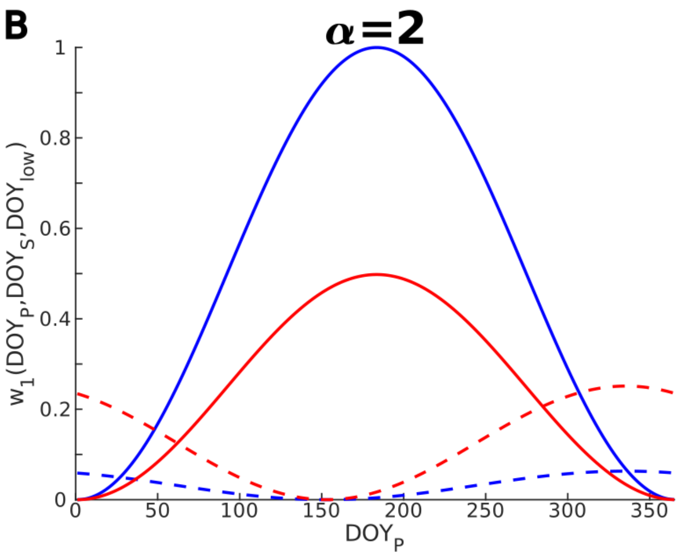
Coherence proxy

Seasonal contribution w_1

$$w_1 = \left| \sin\left(\frac{DOY_P + (365 - DOY_{low})}{365} \times \pi\right) \times \sin\left(\frac{DOY_S + (365 - DOY_{low})}{365} \times \pi\right) \right|^{\alpha}$$

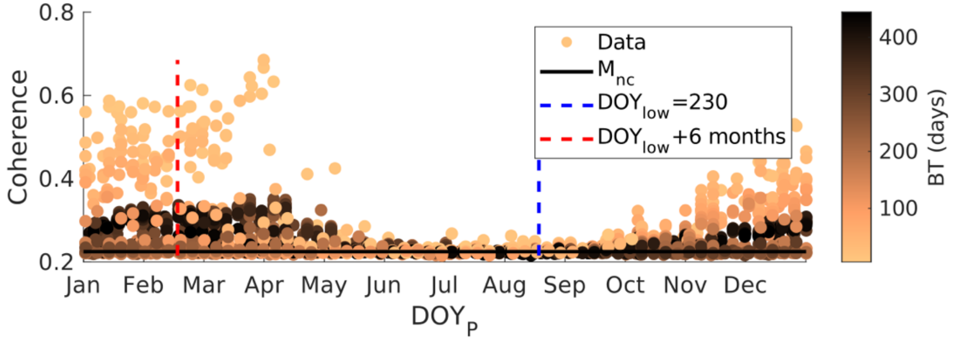


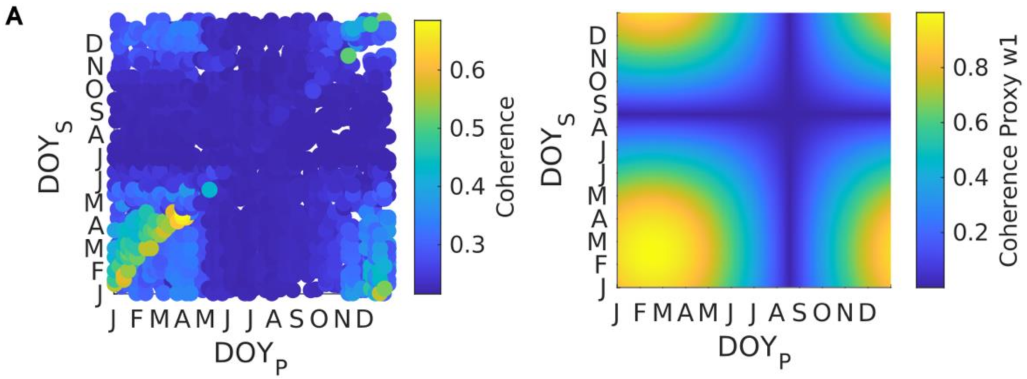


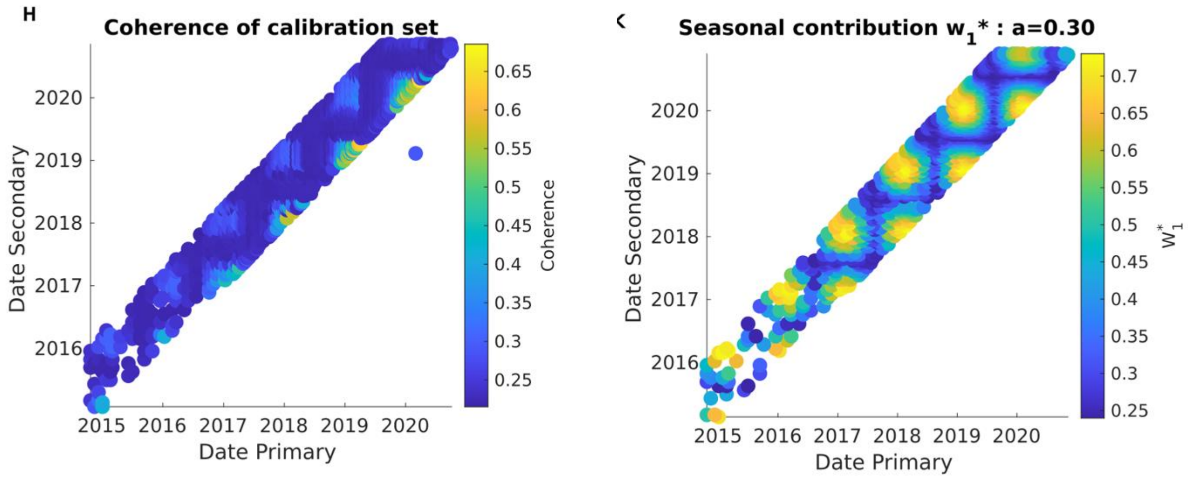


Temporal contribution w_1

$$w_1 = \left| \sin\left(\frac{DOY_P + (365 - DOY_{low})}{365} \times \pi\right) \times \sin\left(\frac{DOY_S + (365 - DOY_{low})}{365} \times \pi\right) \right|^{\alpha}$$



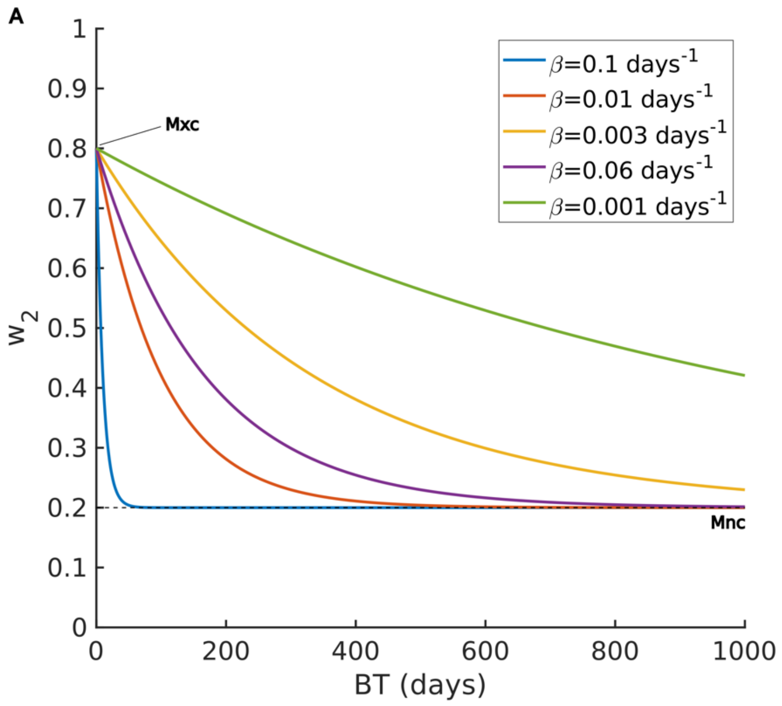




Coherence proxy

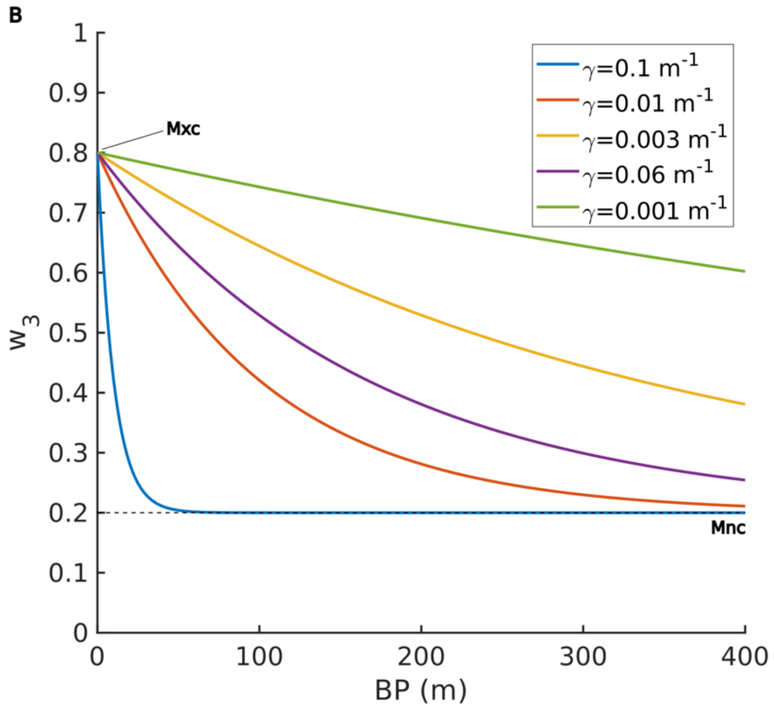
Temporal contribution w_2

$$w_2 = (M_{xc} - M_{nc})e^{-\beta|B_T|} + M_{nc}$$



Spatial contribution w_3

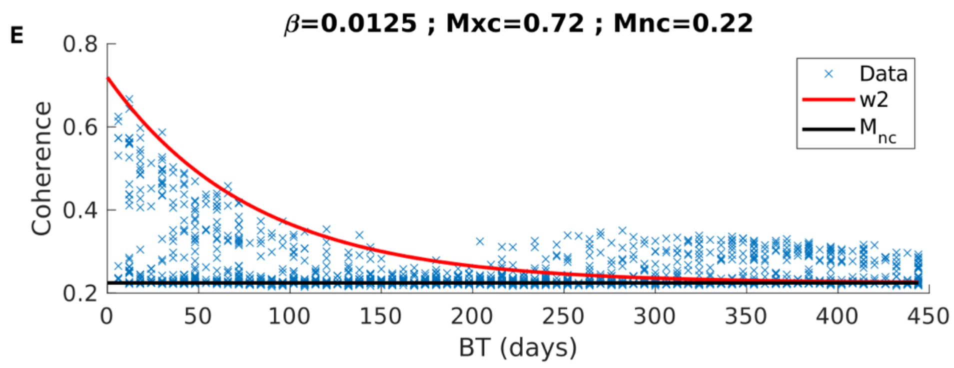
$$w_3 = (M_{xc} - M_{nc})e^{-\gamma|B_P|} + M_{nc}$$

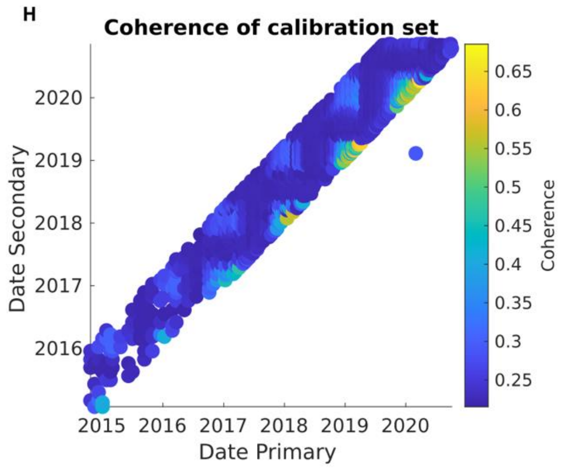


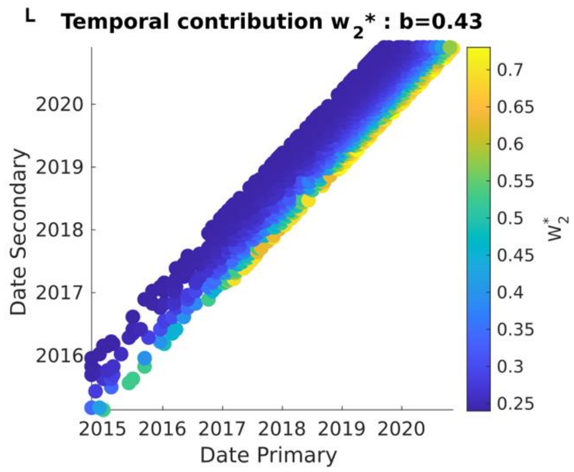
Coherence proxy

Temporal contribution w_2

$$w_2 = (M_{xc} - M_{nc})e^{-\beta|B_T|} + M_{nc}$$

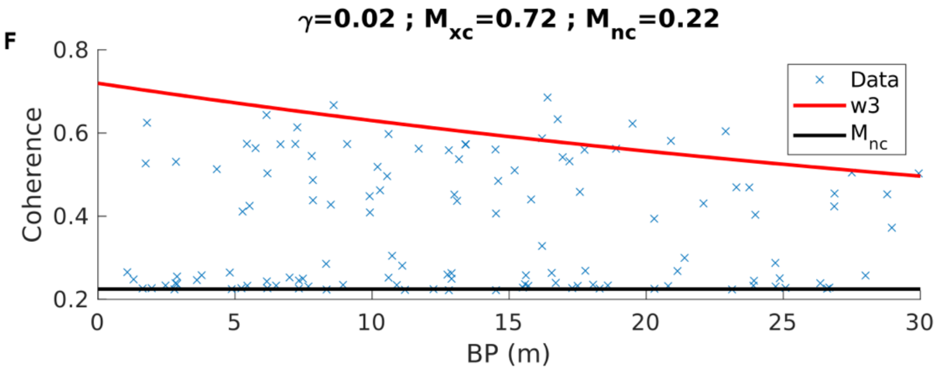


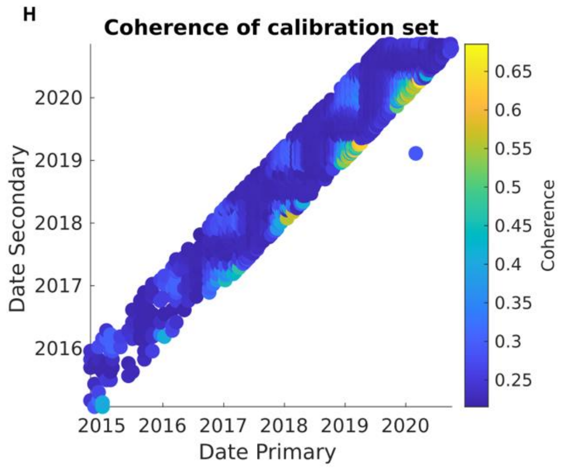


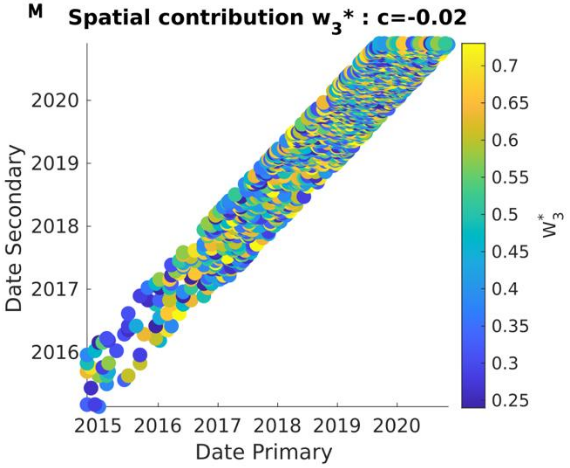


Spatial contribution w_3

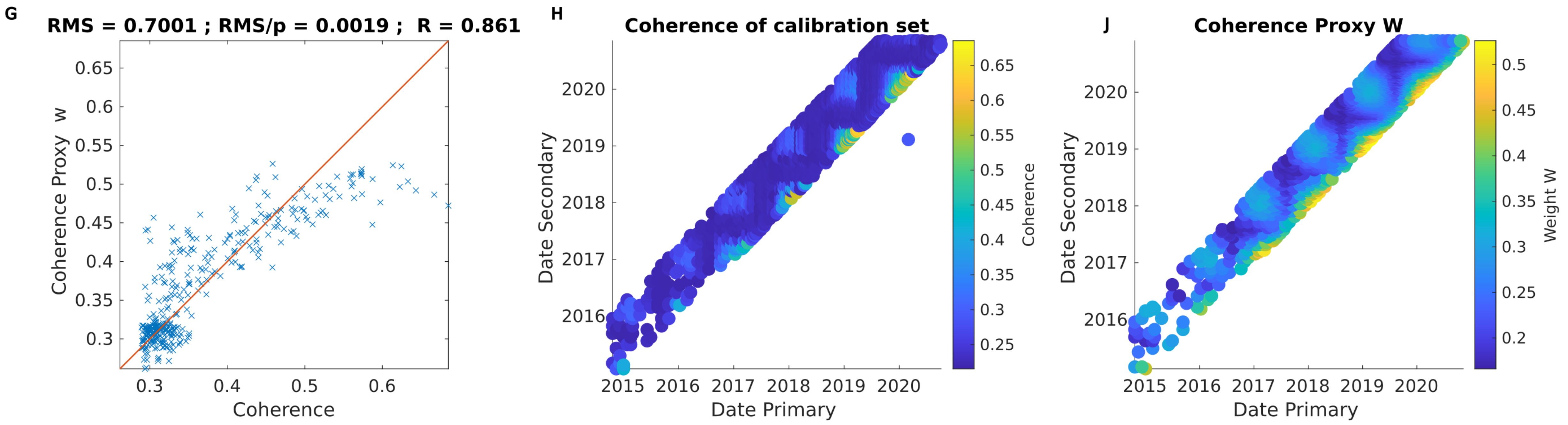
$$w_3 = (M_{xc} - M_{nc})e^{-\gamma|B_P|} + M_{nc}$$







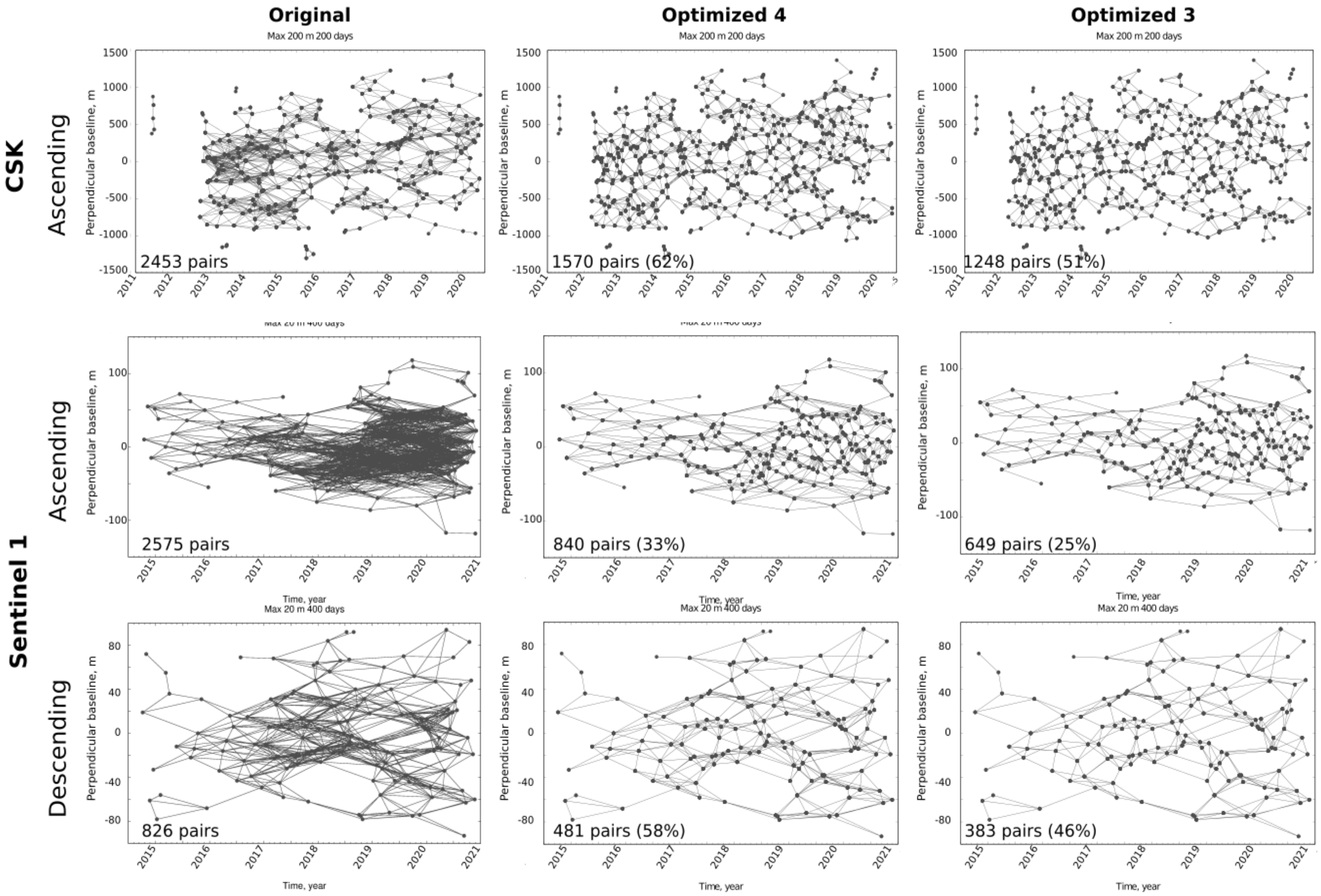
Coherence Vs Coherence Proxy w

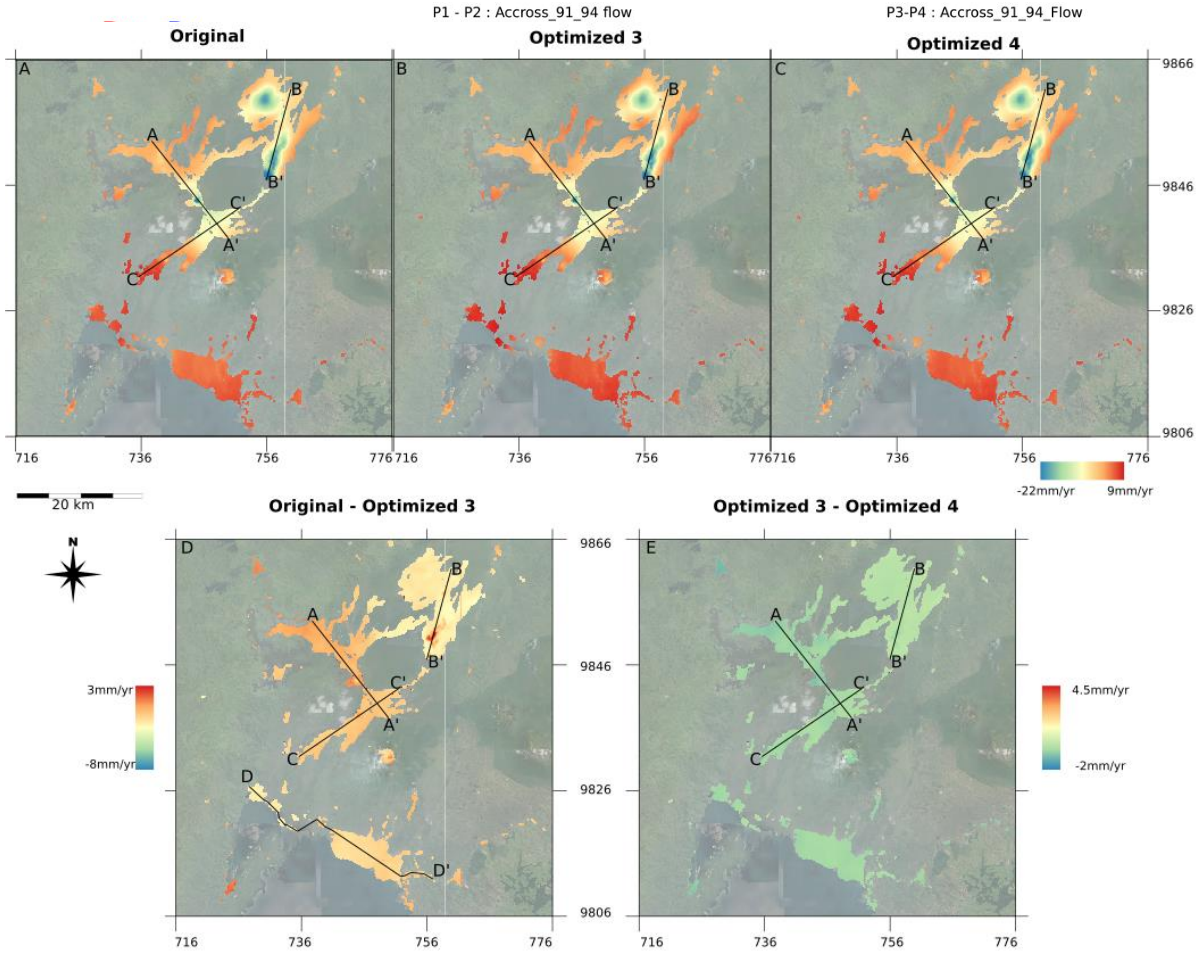


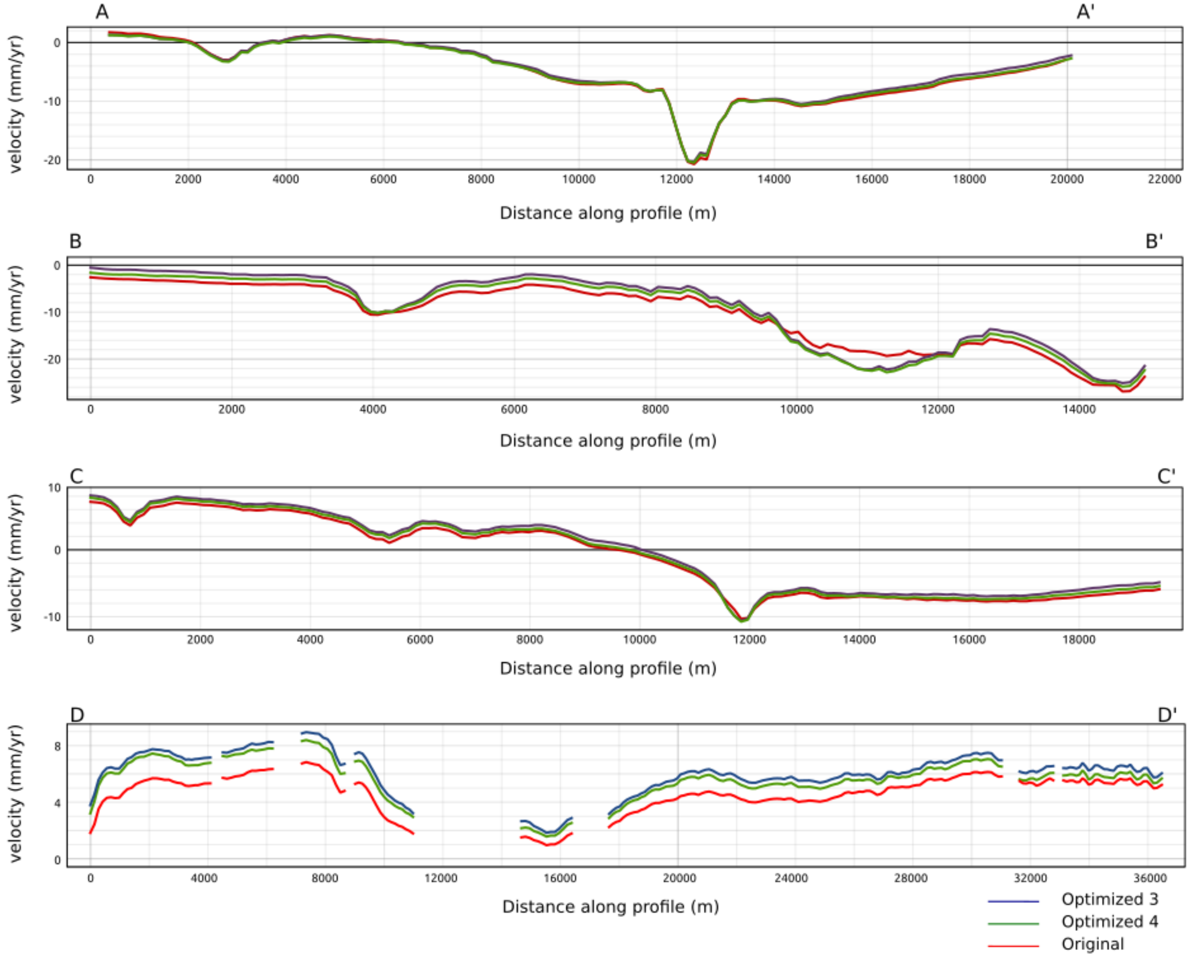
$$w = a\,w_1 + b\,w_2 + c\,w_3$$

a, b and c are inverted using a calibration subset of coherence values for a list of pairs.

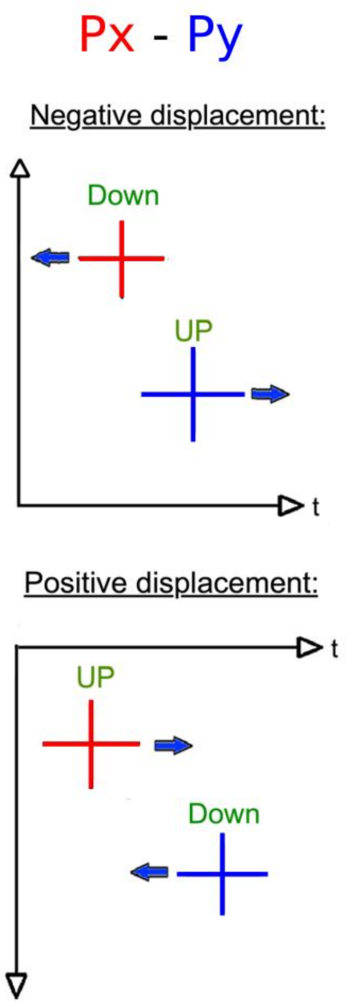
Some results

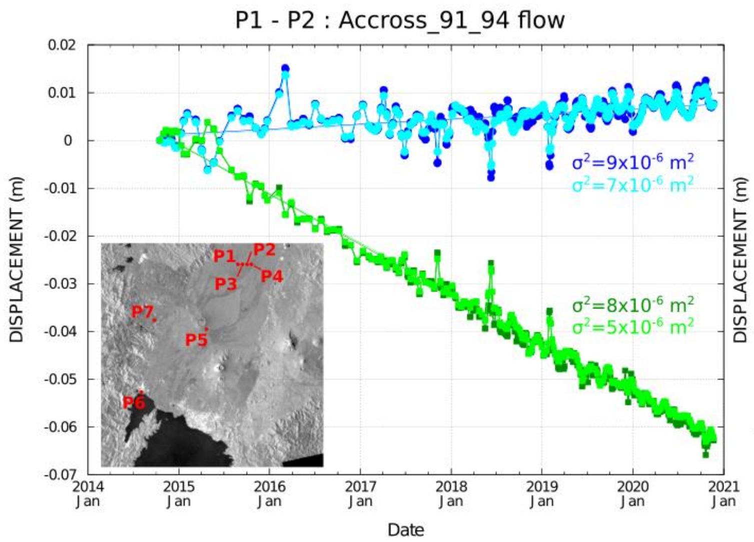


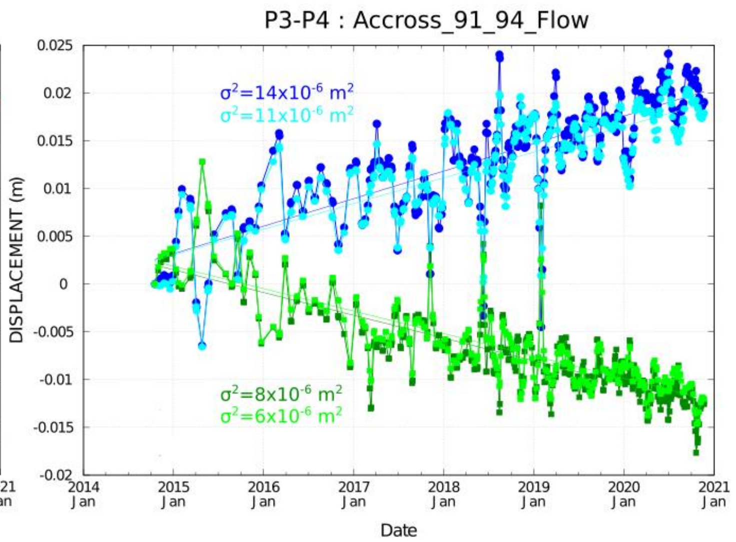

P1 - P2 : Accross_91_94 flow
P3-P4 : Accross_91_94_Flow
Original
Optimized 3
Optimized 4
-22mm/yr
9mm/yr
20 km
Original - Optimized 3
Optimized 3 - Optimized 4
3mm/yr
-8mm/yr
4.5mm/yr
-2mm/yr

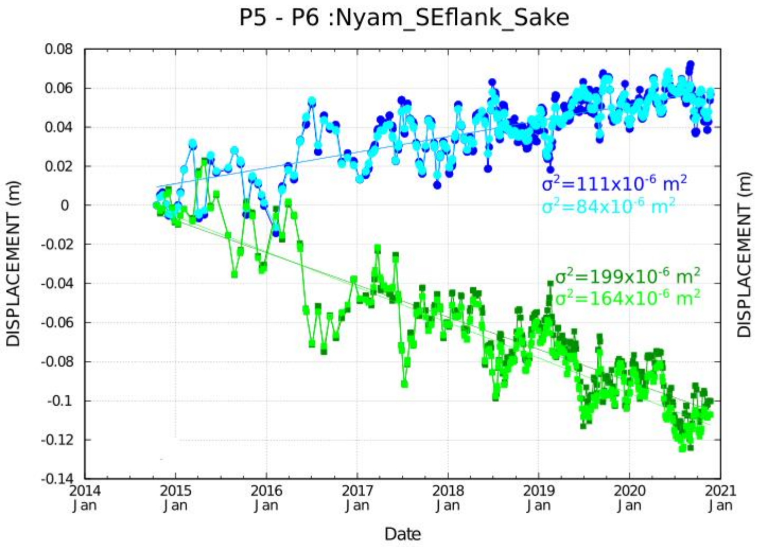

velocity (mm/yr)
Distance along profile (m)
Optimized 3
Optimized 4
Original

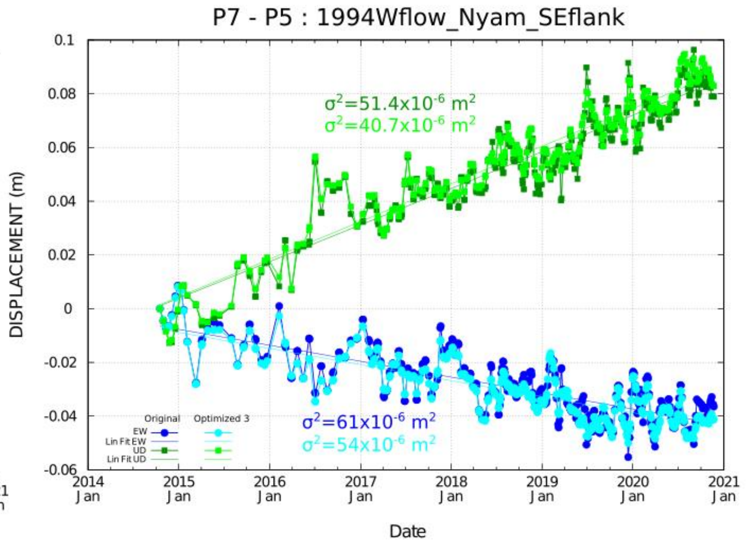
Some results











The optimization toolbox practically

Exercise part 1: Install

Copy optimtoolbox.zip in $HOME/SAR/AMSTer

Open a terminal :

```
cd $HOME/SAR/AMSTer
unzip optimtoolbox.zip
chmod u+x $HOME/SAR/AMSTer/optimtoolbox/*.py
chmod u+x $HOME/SAR/AMSTer/optimtoolbox/*.sh
cd
edit .bashrc
```

Already done if installation performed with ***AMSTer_install.sh***

Add line :

```
PATH=$PATH:$HOME/SAR/AMSTer/optimtoolbox
```

Save and quit text editor

In terminal :

```
source .bashrc
```

The optimization toolbox practically

Exercise part 2: How to use

- Prepare a kml defining your calibration ROI in $PATH_1650/kml/ARGENTINA/Domuyo_Edifice.kml

- Prepare Coherence table calibration

    cd $PATH_3601/SAR_MASSPROCESS/S1/ARG_DOMU_LAGUNA_A_18_SAMPLE/…
    …SMNoCrop_SM_20180512_Zoom1_ML4/Geocoded/Coh
    Baseline_Coh_Table.sh $PATH_1650/kml/ARGENTINA/Domuyo_Edifice.kml

Output is a text file in …/Geocoded/Coh/Baseline_Coh_Table_Domuyo_Edifice.kml.txt

The optimization toolbox practically

Exercise part 2: How to use

- Optimize Pair table

 cd $PATH_1650/SAR_SM/MSBAS/ARGENTINE/set1

 Check if table.orig already exists

Option 1 : Run using coherence values (4 arguments – same pairs in both tables)

Run_optim_module.sh $PATH_1650/SAR_SM/MSBAS/…/seti/table_0_BP_0_BT.txt $PATH_3601/SAR_MASSPROCESS/…/Geocoded/Coh/Baseline_Coh_Table_kml.txt optimdegree coh_thres

 Example :

 Run_optim_module.sh $PATH_1650/SAR_SM/MSBAS/ARGENTINE/set1/table_0_20_0_450.txt_For_Optim.txt $PATH_3601/SAR_MASSPROCESS/S1/ARG_DOMU_LAGUNA_A_18_SAMPLE/SMNoCrop_SM_20180512_Zoom1_ML4… …/Geocoded/Coh/Baseline_Coh_Table_Domuyo_Edifice.kml.txt 3 0

- Optimize Pair table

 Output are textfiles in $PATH_1650/SAR_SM/MSBAS/ARGENTINE/set1/

  table_0_20_0_450_listPR2rm4optim_3_th0.txt
  table_0_20_0_450_listPR2rm4optim_3_th0_optimized.txt
  table_0_20_0_450_orig.txt

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Exercise part 2: How to use

- Optimize Pair table

  cd $PATH_1650/SAR_SM/MSBAS/ARGENTINE/set1

  Check if table.orig already exists

Option 2 : Run using coherence proxy (10 arguments)

Run_optim_module.sh $PATH_1650/SAR_SM/MSBAS/…/seti/table_0_20_0_450.txt $PATH_3601/SAR_MASSPROCESS/…/Geocoded/Coh/Baseline_Coh_Table_.kml.txt optimdegree DOY_{low} α β γ *Mxc* *Mnc* *coh_thres*

Example :

Run_optim_module.sh $PATH_1650/SAR_SM/MSBAS/ARGENTINE/set1/table_0_20_0_450.txt
$PATH_3601/SAR_MASSPROCESS/S1/ARG_DOMU_LAGUNA_A_18_SAMPLE/SMNoCrop_SM_20180512_Zoom1_ML4…
…/Geocoded/Coh/Baseline_Coh_Table_Domuyo_Edifice.kml.txt 3 230 1 0.0125 0.02 0.72 0.22 0

- Optimize Pair table

  Output are textfiles in $PATH_1650/SAR_SM/MSBAS/ARGENTINE/set1/

  table_0_20_0_450_listPR2rm4optim_3_th0.txt
  table_0_20_0_450_listPR2rm4optim_3_th0_optimized.txt
  table_0_20_0_450_orig.txt

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The optimization toolbox practically

Exercise part 2: How to use

- Prepare MSBAS

    cd $PATH_3602/MSBAS/_Argentina_S1_20m_450days

If not already done : **build_header_msbas_criteria.sh**

Save a copy of DefoInterpolx2Detrend1.txt

    cp DefoInterpolx2Detrend1.txt DefoInterpolx2Detrend1_orig.txt

For each set of interest (here only set 1) :

    Remove_Pairs_From_BaselinePlotOptimisation.sh DefoInterpolx2Detrend1
    $PATH_1650/SAR_SM/MSBAS/ARGENTINE/set1/table_0_20_0_450_listPR2rm4optim_3_th0.txt

Output is a text file DefoInterpolx2Detrend1_Optimized_TABLE.txt_RUNTIME.txt

To run msbas without optimization :

cp DefoInterpolx2Detrend1_orig.txt DefoInterpolx2Detrend1.txt

To run msbas with optimized table :

cp DefoInterpolx2Detrend1_Optimized_table_0_20_0_450_listPR2rm4optim_3_th0.txt_05_16_2023_13h43m.txt DefoInterpolx2Detrend1.txt

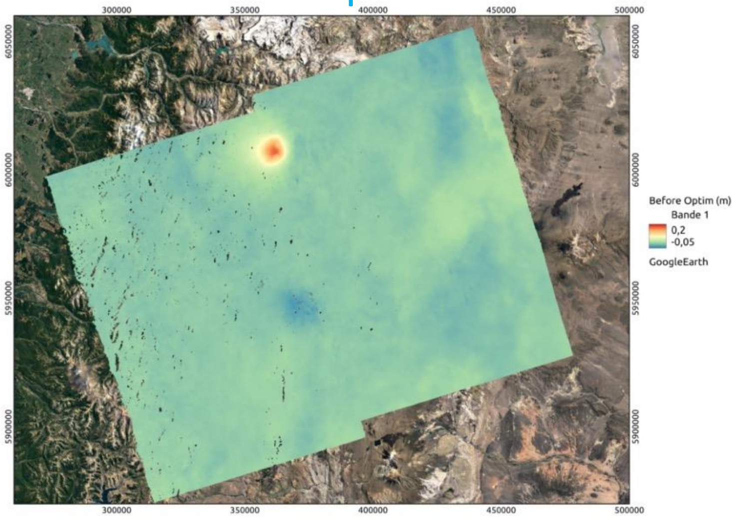
Update header.txt : here only one set, comment line for set 2

Launch : **MSBAS.sh** _set1_afteroptim

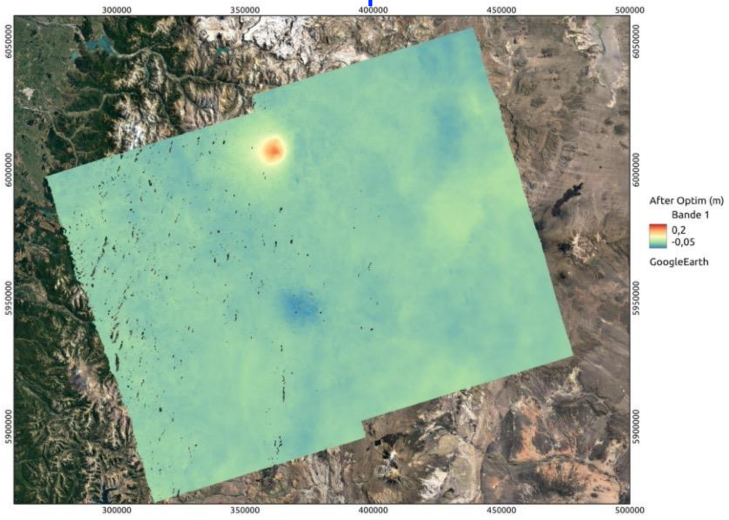
cd zz_LOS_set1_afteroptim

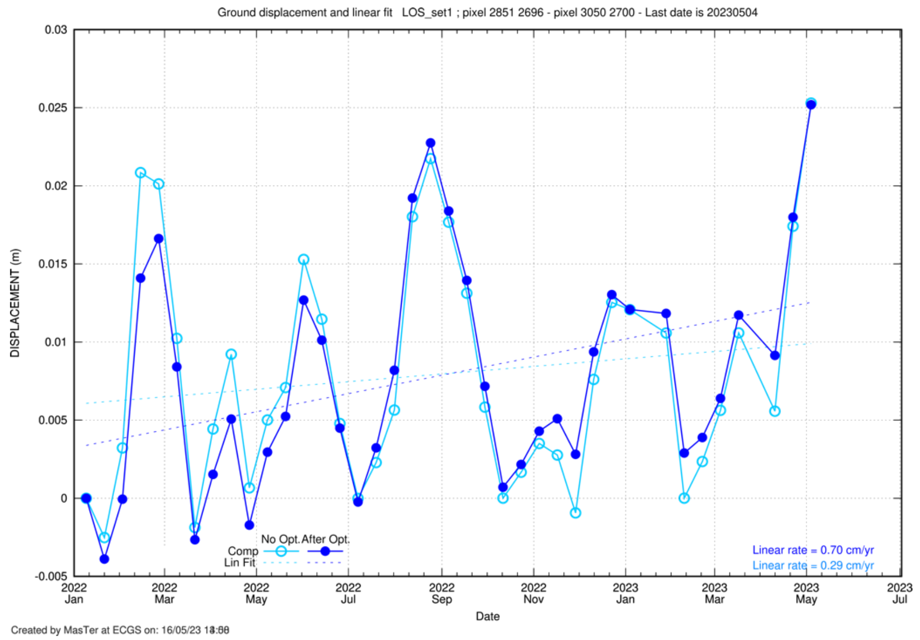
Visualization : **PlotTS.sh** 2851 2696 3050 2700 -f -r -t or open maps in QGIS

No Optim.



After Optim.





Difference